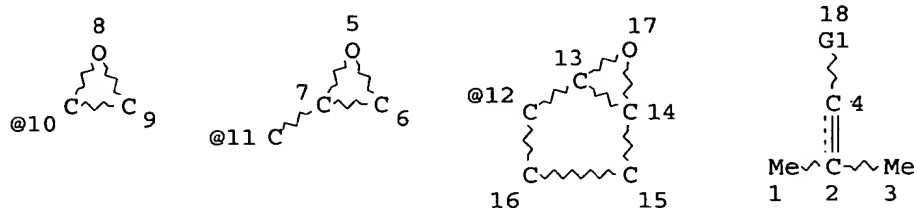


=&gt; d que 122

L5 311 SEA FILE=HCAPLUS ABB=ON PLU=ON "POLYMERIZATION CATALYSTS (L)  
LEWIS ACID"+PFT/CT  
L6 5455 SEA FILE=HCAPLUS ABB=ON PLU=ON LEWIS ACIDS+NT/CT  
L14 STR



VAR G1=11/10/12  
NODE ATTRIBUTES:  
DEFAULT MLEVEL IS ATOM  
DEFAULT ECLEVEL IS LIMITED



GRAPH ATTRIBUTES:  
RING(S) ARE ISOLATED OR EMBEDDED  
NUMBER OF NODES IS 18

STEREO ATTRIBUTES: NONE

L16 965 SEA FILE=REGISTRY SSS FUL L14  
L17 107 SEA FILE=HCAPLUS ABB=ON PLU=ON L16(L) (RACT OR RGT OR RCT)/RL  
  
L18 3 SEA FILE=HCAPLUS ABB=ON PLU=ON L17 AND (L5 OR L6 OR LEWIS)  
L21 2 SEA FILE=HCAPLUS ABB=ON PLU=ON L17 AND ?LUMIN?  
L22 4 SEA FILE=HCAPLUS ABB=ON PLU=ON L18 OR L21

=&gt; d 122 ibib abs hitind hitstr 1-4

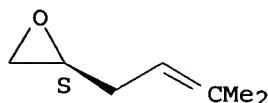
L22 ANSWER 1 OF 4 HCAPLUS COPYRIGHT 2004 ACS on STN  
ACCESSION NUMBER: 2004:751588 HCAPLUS  
DOCUMENT NUMBER: 141:379730  
TITLE: Towards a total synthesis of quinocarcin:  
Diastereoselective synthesis of functionalized  
azepino[1,2-b]isoquinolines  
AUTHOR(S): Koepler, Oliver; Laschat, Sabine; Baro, Angelika;  
Fischer, Peter; Miehl, Burkhard; Hotfilder, Marc;  
le Viseur, Christoph  
CORPORATE SOURCE: Institut fuer Organische Chemie der Technischen  
Universitaet Braunschweig, Braunschweig, 38106,  
Germany  
SOURCE: European Journal of Organic Chemistry (2004), (17),  
3611-3622  
CODEN: EJOCFK; ISSN: 1434-193X  
PUBLISHER: Wiley-VCH Verlag GmbH & Co. KGaA  
DOCUMENT TYPE: Journal  
LANGUAGE: English  
GI

\* STRUCTURE DIAGRAM TOO LARGE FOR DISPLAY - AVAILABLE VIA OFFLINE PRINT \*

- AB 1,3-Disubstituted tetrahydro-oxazolo-isoquinolinones I (R =  $\alpha$ -CO<sub>2</sub>Et or  $\beta$ -CO<sub>2</sub>Et) were obtained from phenylalanine in seven steps and 42% overall yield by Katritzky's benzotriazole method. The tricyclic oxazolidinone I (R =  $\alpha$ -CO<sub>2</sub>Et) was further converted into amino alc. II (R =  $\alpha$ -CH<sub>2</sub>OMe) by employing a chemoselective reduction of the ester group with LiBH<sub>4</sub>/MeOH. Compound II (R =  $\alpha$ -CH<sub>2</sub>OMe) and the corresponding 1-unsubstituted tetrahydroisoquinoline alc. II (R = H) were converted into aldehydes III and IV, which cyclized in the presence of different **Lewis** acids to give the substituted azepino[1,2-b]isoquinolines V and VI, resp., which are key structural features of the alkaloid quinocarcin (VII). The stereoselectivities of the **Lewis**-acid-catalyzed heteroene reaction are highly dependent on the substitution pattern and the type of **Lewis** acid.
- CC 26-6 (Biomolecules and Their Synthetic Analogs)  
Section cross-reference(s): 1, 27
- ST asym synthesis azepinoisoquinoline **Lewis** acid catalyzed heteroene cyclization quinocarcin; antitumor agent human Ewing's sarcoma azepinoisoquinoline quinocarcin
- IT Cyclization catalysts  
(**Lewis** acid-catalyzed hetero-ene cyclization catalysts; diastereoselective synthesis of functionalized azepino[1,2-b]isoquinolines)
- IT Addition reaction catalysts  
(ene, **Lewis** acid-catalyzed hetero-ene cyclization catalysts; diastereoselective synthesis of functionalized azepino[1,2-b]isoquinolines)
- IT Addition reaction  
(ene, stereoselective, **Lewis** acid-catalyzed hetero-ene cyclization; diastereoselective synthesis of functionalized azepino[1,2-b]isoquinolines)
- IT Cyclization  
(stereoselective, **Lewis** acid-catalyzed hetero-ene cyclization; diastereoselective synthesis of functionalized azepino[1,2-b]isoquinolines)
- IT 2510-33-0P 215928-81-7P 219640-74-1P 223460-44-4P 782500-81-6P  
782500-84-9P 782500-85-0P 782500-86-1P 782500-87-2P  
**782500-89-4P** 782500-90-7P 782500-91-8P 782500-92-9P  
782500-93-0P 782500-95-2P 782500-96-3P 782500-97-4P 782501-01-3P  
782501-02-4P 782501-04-6P  
RL: **RCT** (**Reactant**); SPN (Synthetic preparation); PREP (Preparation); **RACT** (**Reactant or reagent**)  
(diastereoselective synthesis of functionalized azepino[1,2-b]isoquinolines)
- IT 109-63-7 563-43-9, **Ethylaluminum** dichloride, reactions  
7550-45-0, Titanium tetrachloride, reactions 7646-78-8, Tin tetrachloride, reactions 7646-85-7, Zinc (II) chloride, reactions  
RL: RGT (Reagent); **RACT** (**Reactant or reagent**)  
(diastereoselective synthesis of functionalized azepino[1,2-b]isoquinolines)
- IT **782500-89-4P**  
RL: **RCT** (**Reactant**); SPN (Synthetic preparation); PREP (Preparation); **RACT** (**Reactant or reagent**)  
(diastereoselective synthesis of functionalized azepino[1,2-b]isoquinolines)
- RN 782500-89-4 HCAPLUS
- CN Oxirane, (3-methyl-2-butenyl)-, (2S)- (9CI) (CA INDEX NAME)



Absolute stereochemistry. Rotation (+).



REFERENCE COUNT: 55 THERE ARE 55 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L22 ANSWER 2 OF 4 HCAPLUS COPYRIGHT 2004 ACS on STN

ACCESSION NUMBER: 2003:385564 HCAPLUS

DOCUMENT NUMBER: 139:117351

TITLE: Biomimetic Synthesis of Fused Polypyrans:  
Oxacyclization Stereo- and Regioselectivity Is a  
Function of the Nucleophile

AUTHOR(S): Bravo, Fernando; McDonald, Frank E.; Neiwert, Wade A.;  
Do, Bao; Hardcastle, Kenneth I.

CORPORATE SOURCE: Department of Chemistry, Emory University, Atlanta,  
GA, 30322, USA

SOURCE: Organic Letters (2003), 5(12), 2123-2126

CODEN: ORLEF7; ISSN: 1523-7060

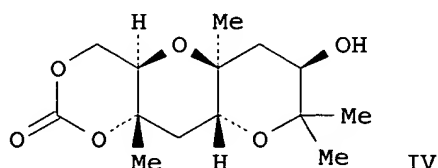
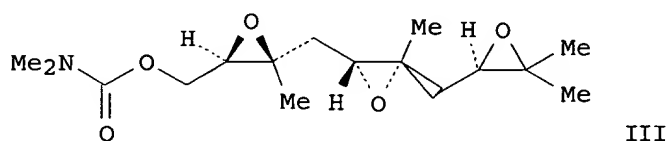
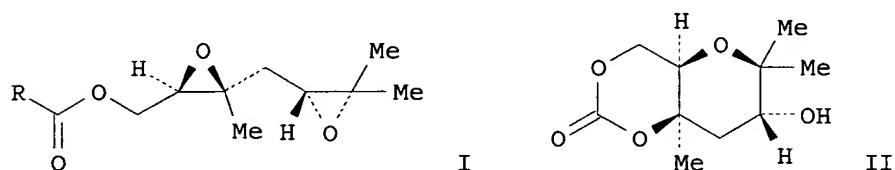
PUBLISHER: American Chemical Society

DOCUMENT TYPE: Journal

LANGUAGE: English

OTHER SOURCE(S): CASREACT 139:117351

GI



AB The stereoselectivity of Lewis acid-induced endo-regioselective oxacyclizations of 1,4-diepoxydes is dependent upon the nature of the terminating nucleophile. For instance, ring-opening/recyclization of the carbonate-substituted diepoxyde I (R = Me3CO) provides a cis-fused bicyclic product II, whereas carbamate-derived I (R = Me2N) affords the

trans-fused diastereomer of II. Stereospecific and regioselective conversion of the tertiary carbamate-terminated 1,4,7-triepoxyde III to tricyclic all-trans-fused polypyran IV is also demonstrated.

CC 28-2 (Heterocyclic Compounds (More Than One Hetero Atom))

IT 565183-88-2P

RL: RCT (Reactant); SPN (Synthetic preparation); PREP (Preparation); RACT (Reactant or reagent)

(allylic oxidation; biomimetic synthesis of pyranodioxanes, furanopyrans and pyranopyrans via regio- and stereoselective ring opening/oxacyclization of carbonate- and carbamate-derivatized diepoxides and triepoxides)

IT 565183-76-8P 565183-77-9P 565183-78-0P 565183-80-4P 565183-82-6P  
565183-84-8P 565183-90-6P 565183-91-7P 565183-92-8P  
565183-93-9P 565183-94-0P 565183-95-1P 565183-96-2P  
565183-98-4P

RL: RCT (Reactant); SPN (Synthetic preparation); PREP (Preparation); RACT (Reactant or reagent)

(biomimetic synthesis of pyranodioxanes, furanopyrans and pyranopyrans via regio- and stereoselective ring opening/oxacyclization of carbonate- and carbamate-derivatized diepoxides and triepoxides)

IT 43161-23-5P 565183-74-6P 565183-79-1P  
565183-81-5P 565183-83-7P 565183-89-3P

RL: RCT (Reactant); SPN (Synthetic preparation); PREP (Preparation); RACT (Reactant or reagent)

(epoxidn.; biomimetic synthesis of pyranodioxanes, furanopyrans and pyranopyrans via regio- and stereoselective ring opening/oxacyclization of carbonate- and carbamate-derivatized diepoxides and triepoxides)

IT 565183-88-2P

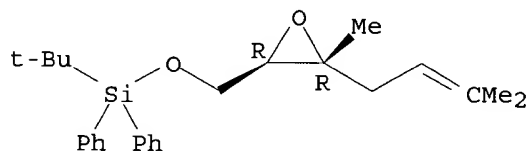
RL: RCT (Reactant); SPN (Synthetic preparation); PREP (Preparation); RACT (Reactant or reagent)

(allylic oxidation; biomimetic synthesis of pyranodioxanes, furanopyrans and pyranopyrans via regio- and stereoselective ring opening/oxacyclization of carbonate- and carbamate-derivatized diepoxides and triepoxides)

RN 565183-88-2 HCAPLUS

CN Silane, (1,1-dimethylethyl)[[(2R,3R)-3-methyl-3-(3-methyl-2-butenyl)oxiranyl]methoxy]diphenyl- (9CI) (CA INDEX NAME)

Absolute stereochemistry. Rotation (+).



IT 565183-92-8P 565183-93-9P 565183-94-0P

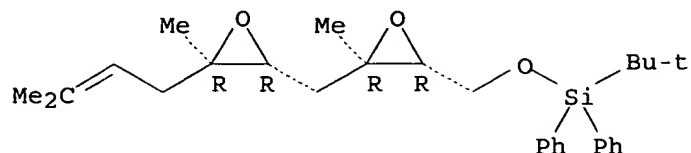
RL: RCT (Reactant); SPN (Synthetic preparation); PREP (Preparation); RACT (Reactant or reagent)

(biomimetic synthesis of pyranodioxanes, furanopyrans and pyranopyrans via regio- and stereoselective ring opening/oxacyclization of carbonate- and carbamate-derivatized diepoxides and triepoxides)

RN 565183-92-8 HCAPLUS

CN L-gluco-Heptitol, 2,3:5,6-dianhydro-4,7-dideoxy-1-O-[(1,1-dimethylethyl)diphenylsilyl]-3-C-methyl-6-C-(3-methyl-2-butenyl)- (9CI) (CA INDEX NAME)

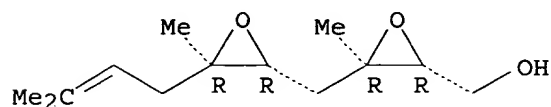
Absolute stereochemistry.



RN 565183-93-9 HCAPLUS

CN L-glucitol, 2,3:5,6-dianhydro-4,7-dideoxy-3-C-methyl-6-C-(3-methyl-2-butenyl)- (9CI) (CA INDEX NAME)

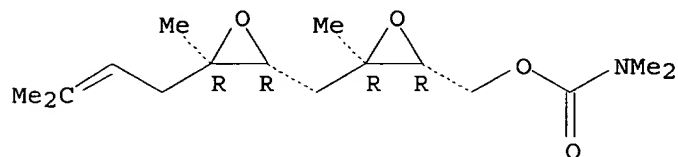
Absolute stereochemistry. Rotation (+).



RN 565183-94-0 HCAPLUS

CN L-glucitol, 2,3:5,6-dianhydro-4,7-dideoxy-3-C-methyl-6-C-(3-methyl-2-butenyl)-, dimethylcarbamate (9CI) (CA INDEX NAME)

Absolute stereochemistry. Rotation (+).



IT 565183-74-6P 565183-79-1P 565183-81-5P

565183-83-7P

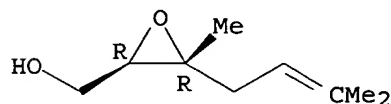
RL: RCT (Reactant); SPN (Synthetic preparation); PREP (Preparation); RACT (Reactant or reagent)

(epoxidn.; biomimetic synthesis of pyranodioxanes, furanopyrans and pyranopyrans via regio- and stereoselective ring opening/oxacyclization of carbonate- and carbamate-derivatized diepoxides and triepoxides)

RN 565183-74-6 HCAPLUS

CN Oxiranemethanol, 3-methyl-3-(3-methyl-2-butenyl)-, (2R,3R)- (9CI) (CA INDEX NAME)

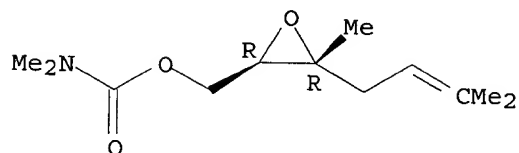
Absolute stereochemistry. Rotation (+).



RN 565183-79-1 HCAPLUS

CN Carbamic acid, dimethyl-, [(2R,3R)-3-methyl-3-(3-methyl-2-butenyl)oxiranyl]methyl ester (9CI) (CA INDEX NAME)

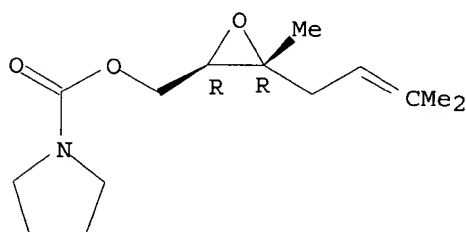
Absolute stereochemistry. Rotation (+).



RN 565183-81-5 HCAPLUS

CN 1-Pyrrolidinecarboxylic acid, [(2R,3R)-3-methyl-3-(3-methyl-2-butenyl)oxiranyl]methyl ester (9CI) (CA INDEX NAME)

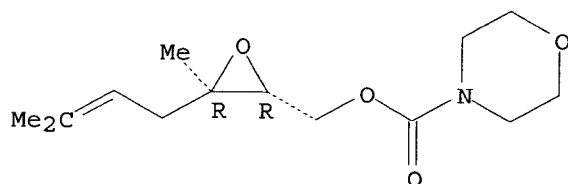
Absolute stereochemistry.



RN 565183-83-7 HCAPLUS

CN 4-Morpholinecarboxylic acid, [(2R,3R)-3-methyl-3-(3-methyl-2-butenyl)oxiranyl]methyl ester (9CI) (CA INDEX NAME)

Absolute stereochemistry.



REFERENCE COUNT: 42 THERE ARE 42 CITED REFERENCES AVAILABLE FOR THIS RECORD. ALL CITATIONS AVAILABLE IN THE RE FORMAT

L22 ANSWER 3 OF 4 HCAPLUS COPYRIGHT 2004 ACS on STN

ACCESSION NUMBER: 1993:538472 HCAPLUS

DOCUMENT NUMBER: 119:138472

TITLE: A tellurium transposition route to allylic alcohols: overcoming some limitations of the Sharpless-Katsuki asymmetric epoxidation

AUTHOR(S): Dittmer, Donald C.; Discordia, Robert P.; Zhang, Yanzhi; Murphy, Christopher K.; Kumar, Archana; Pepito, Aurora S.; Wang, Yuesheng

CORPORATE SOURCE: Cent. Sci. Technol., Syracuse Univ., Syracuse, NY, 13244, USA

SOURCE: Journal of Organic Chemistry (1993), 58(3), 718-31  
CODEN: JOCEAH; ISSN: 0022-3263

DOCUMENT TYPE: Journal

LANGUAGE: English

OTHER SOURCE(S): CASREACT 119:138472

AB Good yields of enantiomeric allylic alcs. can be obtained in high enantiomeric excess (ee) by combining the Sharpless-Katsuki asym. epoxidn. process (SAE) with tellurium chemical. The advantages of the tellurium process are as follows: (1) the 50% yield limitation on the allylic alc. in the Sharpless kinetic resolution (SKR) can be overcome; (2) allylic tertiary alcs. which are unsatisfactory substrates in the SKR can be obtained in high optical purity; (3) optically active secondary allylic alcs. with tertiary alkyl substituents (e.g. tert-butyl) at C-1 can be obtained in high ee; (4) optically active sterically congested cis secondary alcs. can be obtained in high ee; and (5) the nuisance of the slow SAE of some vinyl carbinols can be avoided. The key step in the reaction sequence is either a stereospecific 1,3-transposition of double bond and alc. functionalities or an inversion of the alc. configuration with concomitant deoxygenation of the epoxide function in epoxy alcs. Trans secondary allylic alcs. can be converted to cis secondary allylic alcs. by way of erythro epoxy alcs. (glycidols); threo glycidyl derivs. are converted to trans secondary allylic alcs. These transformations are accomplished by the action of telluride ion, generated in situ from the element, on a glycidyl sulfonate ester. Reduction of elemental Te is conveniently done with rongalite (HOCH<sub>2</sub>SO<sub>2</sub>Na) in an aqueous medium. This method is satisfactory when Te<sup>2-</sup> is required to attack a primary carbon site of a glycidyl sulfonate. In cases where Te<sup>2-</sup> is required to attack a secondary carbon site, reduction of the tellurium must be done with NaBH<sub>4</sub> or LiEt<sub>3</sub>BH. Elemental tellurium is precipitated during the course of the

reactions

and can be recovered and reused.

CC 21-2 (General Organic Chemistry)

Section cross-reference(s): 26

IT 80232-50-4P 80287-12-3P 111321-48-3P 121401-06-7P  
 121468-44-8P 121958-41-6P 131750-35-1P 131750-36-2P 131750-37-3P  
 131750-38-4P 131831-36-2P 131831-37-3P 131831-38-4P 131831-39-5P  
 147048-00-8P 147048-01-9P 147048-07-5P 147048-10-0P 147048-16-6P  
 147127-69-3P 147127-70-6P 147127-73-9P 147127-79-5P 147127-80-8P  
 147493-35-4P 200205-69-2P

RL: RCT (Reactant); SPN (Synthetic preparation); PREP

(Preparation); RACT (Reactant or reagent)

(preparation and reaction of, with telluride ion)

IT 147048-17-7P

RL: RCT (Reactant); SPN (Synthetic preparation); PREP (Preparation); RACT

(Reactant or reagent)

(preparation and reduction of, with lithium aluminum hydride)

IT 62777-71-3P, (2R,3R)-2,3-Epoxygeraniol 78513-12-9P 80232-49-1P  
 80299-55-4P 82188-73-6P 84039-81-6P 89194-12-7P  
 97589-09-8P 107033-45-4P 107796-93-0P 114180-68-6P 114180-70-0P  
 147047-99-2P 147048-15-5P 147048-20-2P 147127-72-8P 147127-74-0P  
 147127-77-3P 147127-81-9P 147129-38-2P 147600-50-8P 161511-98-4P

RL: RCT (Reactant); SPN (Synthetic preparation); PREP

(Preparation); RACT (Reactant or reagent)

(preparation and tosylation of)

IT 18448-47-0, Methyl 1-cyclohexene-1-carboxylate

RL: RCT (Reactant); RACT (Reactant or reagent)

(reduction of, with lithium aluminum hydride)

IT 80232-50-4P 80287-12-3P

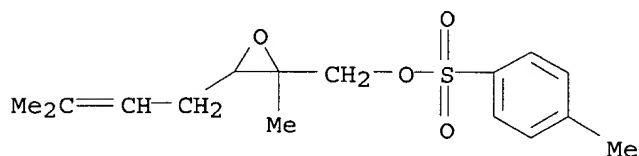
RL: RCT (Reactant); SPN (Synthetic preparation); PREP

(Preparation); RACT (Reactant or reagent)

(preparation and reaction of, with telluride ion)

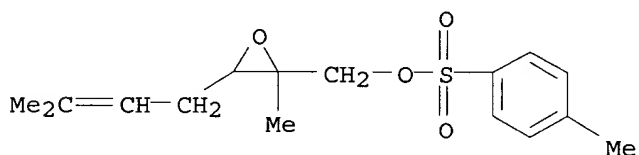
RN 80232-50-4 HCAPLUS

CN Oxiranemethanol, 2-methyl-3-(3-methyl-2-butenyl)-, 4-methylbenzenesulfonate, (2R-trans)- (9CI) (CA INDEX NAME)



RN 80287-12-3 HCAPLUS

CN Oxiranemethanol, 2-methyl-3-(3-methyl-2-butenyl)-, 4-methylbenzenesulfonate, (2S-trans)- (9CI) (CA INDEX NAME)



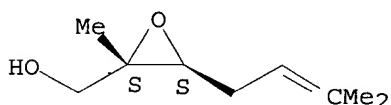
IT 80232-49-1P 80299-55-4P

RL: **RCT (Reactant)**; SPN (Synthetic preparation); PREP (Preparation); **RACT (Reactant or reagent)** (preparation and tosylation of)

RN 80232-49-1 HCAPLUS

CN Oxiranemethanol, 2-methyl-3-(3-methyl-2-butenyl)-, (2S-trans)- (9CI) (CA INDEX NAME)

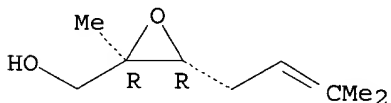
Absolute stereochemistry.



RN 80299-55-4 HCAPLUS

CN Oxiranemethanol, 2-methyl-3-(3-methyl-2-butenyl)-, (2R,3R)- (9CI) (CA INDEX NAME)

Absolute stereochemistry. Rotation (+).



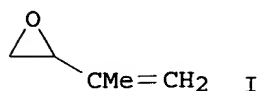
L22 ANSWER 4 OF 4 HCAPLUS COPYRIGHT 2004 ACS on STN

ACCESSION NUMBER: 1988:37183 HCAPLUS

DOCUMENT NUMBER: 108:37183

TITLE: Highly regioselective addition of allylstannanes to vinyl epoxides by Lewis acid mediation

AUTHOR(S): Naruta, Yoshinori; Maruyama, Kazuhiro  
 CORPORATE SOURCE: Fac. Sci., Kyoto Univ., Kyoto, 606, Japan  
 SOURCE: Chemistry Letters (1987), (5), 963-6  
 CODEN: CMLTAG; ISSN: 0366-7022  
 DOCUMENT TYPE: Journal  
 LANGUAGE: English  
 OTHER SOURCE(S): CASREACT 108:37183  
 GI



AB Allylic trimethylstannes react with vinyl epoxides in the presence of BF<sub>3</sub>·OEt<sub>2</sub> to give 1,2- or 1,4-addition products in good yield, depending on the substitution at the olefinic terminus. In either case regioselectivity is high. E.g., epoxymethylbutene I was treated with Me<sub>2</sub>C:CHCH<sub>2</sub>SnMe<sub>3</sub> to give 91% CH<sub>2</sub>:CHCMe<sub>2</sub>CH(CH<sub>2</sub>OH)CMe:CH<sub>2</sub>, which then underwent Cope rearrangement on treatment with DBU to give 100% of a 58:42 mixture of (E)- and (Z)-HOCH<sub>2</sub>CH:CMeCH<sub>2</sub>CH<sub>2</sub>CH:CMe<sub>2</sub>.

CC 23-7 (Aliphatic Compounds)  
 Section cross-reference(s): 27

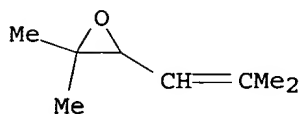
ST addn allylstannane vinyl epoxide regiochem; regiochem allylation vinyl epoxide; stannane allyl allylation vinyl epoxide; **Lewis** acid catalyst allylation regiochem; alkadienol; polyprenyl alc; alc unsatd

IT 1838-94-4 6705-51-7 6790-41-6 7437-61-8 **13295-59-5**  
 50901-75-2  
 RL: **RCT (Reactant); RACT (Reactant or reagent)**  
 (allylation of, with allylic trimethylstannanes, regiochem. of)

IT **13295-59-5**  
 RL: **RCT (Reactant); RACT (Reactant or reagent)**  
 (allylation of, with allylic trimethylstannanes, regiochem. of)

RN 13295-59-5 HCAPLUS

CN Oxirane, 2,2-dimethyl-3-(2-methyl-1-propenyl)- (9CI) (CA INDEX NAME)



1

2



- 9 -

further compression is possible. A method known as tree encoding may, for example, be employed. Moreover, a method called quantization can be employed to further compress the data. Tree encoding and quantization are  
5 described in various texts and articles including "Image Compression using the 2-D Wavelet Transform" by A.S. Lewis and G. Knowles, published in IEEE Transactions on Image Processing, April 1992. Furthermore, video data which comprises sequences of images can be compressed by taking  
10 advantage of the similarities between successive images. Where a portion of successive images does not change from one image to the next, the portion of the first image can be used for the next image, thereby reducing the number of bits necessary to represent the sequence of images.

15 JPEG (Joint Photographics Experts Group) is an international standard for still-images which typically achieves about a 10:1 compression ratios for monochrome images and 15:1 compression ratios for color images. The JPEG standard employs a combination of a type of Fourier  
20 transform, known as the discrete-cosine transform, in combination with quantization and a Huffman-like code. MPEG1 (Motion Picture Experts Group) and MPEG2 are two international video compression standards. MPEG2 is a standard which is still evolving which is targeted for  
25 broadcast television. MPEG2 allows the picture quality to be adjusted to allow more television information to be transmitted, e.g., on a given coaxial cable. H.261 is another video standard based on the discrete-cosine transform. H.261 also varies the amount of compression  
30 depending on the data rate required.

Compression standards such as JPEG, MPEG1, MPEG2 and H.261 are optimized to minimize the signal to noise ratio of the error between the original and the reconstructed image. Due to this optimization, these methods are very  
35 complex. Chips implementing MPEG1, for example, may be costly and require as many as 1.5 million transistors. These methods only partially take advantage of the fact

- 10 -

that the human visual system is quite insensitive to signal to noise ratio. Accordingly, some of the complexity inherent in these standards is wasted on the human eye. Moreover, because these standards encode by  
5 areas of the image, they are not particularly sensitive to edge-type information which is of high importance to the human visual system. In view of these maladaptions of current compression standards to the characteristics of the human visual system, a new compression and  
10 decompression method is sought which handles the above-described boundary problem and which takes advantage of the fact that the human visual system is more sensitive to edge information than signal to noise ratio so that the complexity and cost of implementing the method can be  
15 reduced.

#### SUMMARY

A compression and decompression method using wavelet decomposition, frequency based tree encoding, tree based motion encoding, frequency weighted quantization, Huffman  
20 encoding, and tree based activity estimation for bit rate control is disclosed. Forward and inverse quasi-perfect reconstruction transforms are used to generate the wavelet decomposition and to reconstruct data values close to the original data values. The forward and inverse quasi-  
25 perfect reconstruction transforms utilize special filters at the boundaries of the data being transformed and/or inverse transformed to solve the above-mentioned boundary problem.

In accordance with some embodiments of the present  
30 invention, a decompression method uses four coefficient inverse perfect reconstruction digital filters. The coefficients of these inverse perfect reconstruction digital filters require a small number of additions to implement thereby enabling rapid decompression in software  
35 executing on a general purpose digital computer having a microprocessor. The method partially inverse transforms a

- 11 -

sub-band decomposition to generate a small low frequency component image. This small image is expanded in one dimension by performing interpolation on the rows of the small image and is expanded in a second dimension by replicating rows of the interpolated small image. Transformed chrominance data values are inverse transformed using inverse perfect reconstruction digital filters having a fewer number of coefficients than the inverse perfect reconstruction digital filters used to inverse transform the corresponding transformed luminance data values. In one embodiment, two coefficient Haar digital filters are used as the inverse perfect reconstruction digital filters which inverse transform transformed chrominance data values. Variable-length tokens are used in the compressed data stream to indicate changes in encoding methods used to encode data values in the compressed data stream.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1-4 (Prior Art) are diagrams illustrating a sub-band decomposition of an image.

Figure 5 (Prior Art) is a diagram illustrating a boundary problem associated with the generation of prior art sub-band decompositions.

Figure 6 (Prior Art) is a diagram illustrating a solution to the boundary problem associated with the generation of prior art sub-band decompositions.

Figure 7 is a diagram illustrating a one-dimensional decomposition.

Figures 8 and 9 are diagrams illustrating the separation of an input signal into a high pass component and a low pass component.

Figures 10, 11, 14 and 15 are diagrams illustrating a transformation in accordance with one embodiment of the present invention.

Figures 12 and 13 are diagrams illustrating the operation of high pass and low pass forward transform

- 12 -

digital filters in accordance with one embodiment of the present invention.

Figure 16 is a diagram of a two-dimensional matrix of original data values in accordance with one embodiment of the present invention.

Figure 17 is a diagram of the two-dimensional matrix of Figure 16 after one octave of forward transform in accordance with one embodiment of the present invention.

Figure 18 is a diagram of the two-dimensional matrix of Figure 16 after two octaves of forward transform in accordance with one embodiment of the present invention.

Figures 19 and 20 are diagrams illustrating a boundary problem solved in accordance with one embodiment of the present invention.

Figure 21 is a diagram illustrating the operation of boundary forward transform digital filters in accordance with one embodiment of the present invention.

Figure 22 is a diagram illustrating the operation of start and end inverse transform digital filters in accordance with one embodiment of the present invention.

Figure 23 is a diagram illustrating a one-dimensional tree structure in accordance one embodiment of the present invention.

Figure 24A-D are diagrams illustrating the recursive filtering of data values to generate a one-dimensional decomposition corresponding with the one-dimensional tree structure of Figure 23.

Figure 25 is a diagram of a two-dimensional tree structure of two-by-two blocks of data values in accordance with one embodiment of the present invention.

Figure 26 is a pictorial representation of the data values of the two-dimension tree structure of Figure 25.

Figures 27-29 are diagrams illustrating a method and apparatus for determining the addresses of data values of a tree structure in accordance with one embodiment of the present invention.

Figure 30 and 31 are diagrams illustrating a

- 13 -

quantization of transformed data values in accordance with one embodiment of the present invention.

Figures 32 and 33 are diagrams illustrating the sensitivity of the human eye to spatial frequency.

5        Figures 34 is a diagram illustrating the distribution of high pass component data values in a four octave wavelet decomposition of the test image Lenna.

Figure 35 is a diagram illustrating the distribution of data values of the test image Lenna before wavelet  
10 transformation.

Figure 36 is a block diagram illustrating a video encoder and a video decoder in accordance with one embodiment of the present invention.

Figure 37 is a diagram illustrating modes of the  
15 video encoder and video decoder of Figure 36 and the corresponding token values.

Figure 38 is a diagram illustrating how various flags combine to generate a new mode when the inherited mode is send in accordance with one embodiment of the present  
20 invention.

Figures 39-40 are diagrams of a black box on a white background illustrating motion.

Figures 41-43 are one-dimensional tree structures corresponding to the motion of an edge illustrated in  
25 Figures 39-40.

Figure 44 is a diagram illustrating variable-length tokens in accordance with one embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

##### 30                    QUASI-PERFECT RECONSTRUCTION FILTERS

The wavelet transform was introduced by Jean Morlet in 1984 to overcome problems encountered in analyzing geological signals. See "Cycle-octave and Related Transforms In Seismic Signal Analysis", Goupillaud,  
35 Grossman and Morlet, Geoexploration, vol. 23, 1984. Since then, the wavelet transform has been a new and exciting

- 14 -

method of analyzing signals and has already been applied to a wide range of tasks such as quantum mechanics and signal processing. The wavelet transform has a number of advantages over more traditional Fourier techniques principally used today in the analysis of signals. The wavelet transform and the high and low pass four coefficient quasi-perfect reconstruction filters of the present invention are therefore described by relating them to the windowed Fourier transform.

10 The windowed Fourier transform is the principle transform used today to analyze the spectral components of a signal. The Fourier transform decomposes a signal under analysis into a set of complex sinusoidal basis functions. The resulting Fourier series can be interpreted as the  
15 frequency spectra of the signal. The continuous Fourier transform is defined as follows:

$$F(\omega) = \int_{-\infty}^{\infty} e^{-j2\pi\omega t} f(t) dt \quad (\text{equ. 1})$$

Where  $f(t)$  is the time domain signal under analysis and  $F(\omega)$  is the Fourier transform of the signal under  
20 analysis. Although many applications require an estimate of the spectral content of an input signal, the above formula is impractical for most systems. In order to calculate the Fourier transform, the input signal  $f(t)$  must be defined for all values of time  $t$ , whereas in most  
25 practical systems,  $f(t)$  is only defined over a finite range of time.

Several methods have therefore been devised to transform the finite input signal into an infinite signal so that the Fourier transform can be applied. The  
30 windowed Fourier transform is one such solution. The windowed Fourier transform is defined as follows:

$$F_w(\omega, \tau) = \int_{-\infty}^{\infty} w(t-\tau) e^{-j2\pi\omega t} f(t) dt \quad (\text{equ. 2})$$

Where  $f(t)$  is the time domain signal under analysis,

- 15 -

$F_w(\omega, \tau)$  is the windowed Fourier transform of the time domain signal under analysis, and  $w(t)$  is the windowing function. The windowing function is usually chosen to be zero outside an interval of finite length. Alternatively, as the spectral content of the input  $f(t)$  varies with time, the input signal can be examined by performing the transform at time  $\tau$  using a more local window function. In either case, the output transform is the convolution of the window function and the signal under analysis so that the spectra of the window itself is present in the transform results. Consequently, the windowing function is chosen to minimize this effect. Looking at this technique from another viewpoint, the basis functions of a windowed Fourier transform are not complex sinusoids but rather are windowed complex sinusoids. Dennis Gabor used a real Gaussian function in conjunction with sinusoids of varying frequencies to produce a complete set of basis functions (known as Gabor functions) with which to analyze a signal. For a locality given by the effective width of the Gaussian function, the sinusoidal frequency is varied such that the entire spectrum is covered.

The wavelet transform decomposes a signal into a set of basis functions that can be nearly local in both frequency and time. This is achieved by translating and dilating a function  $\Psi(t)$  that has spatial and spectral locality to form a set of basis functions:

$$\sqrt{s}\Psi(s(t-u)) \quad (\text{equ. 3})$$

wherein  $s$  and  $u$  are real numbers and are the variables of the transform. The function  $\Psi(t)$  is called the wavelet.

The continuous wavelet transform of a signal under analysis is defined as follows:

$$W(s, u) = \sqrt{s} \int_{-\infty}^{\infty} \Psi(s(t-u)) f(t) dt \quad (\text{equ. 4})$$

Where  $f(t)$  is the time domain signal under analysis,

- 16 -

$W(s,u)$  is its wavelet transform,  $\Psi$  is the wavelet,  $s$  is the positive dilation factor and  $u$  is the scaled translation distance. The spatial and spectral locality of the wavelet transform is dependent on the characteristics of the wavelet.

Because the signal under analysis in the compression of digitally sampled images has finite length, the discrete counterpart of the continuous wavelet transform is used. The wavelet transform performs a multiresolution decomposition based on a sequence of resolutions often referred to as "octaves". The frequencies of consecutive octaves vary uniformly on a logarithmic frequency scale. This logarithmic scale can be selected so that consecutive octaves differ by a factor of two in frequency. The basis functions are:

$$\{\psi^j(x-2^{-j}n)\} \text{ for } (j,n) \in \mathbb{Z}^2 \quad (\text{equ. 5})$$

where  $\mathbb{Z}$  is the set of all integers,  $\mathbb{Z}^2 = \{(j,n) : j,n \in \mathbb{Z}\}$ , and  $\psi^j(x) = \sqrt{2^j} \psi(2^j x)$ .

In a sampled system, a resolution  $r$  signifies that the signal under analysis has been sampled at  $r$  samples per unit length. A multiresolution analysis studies an input signal at a number of resolutions, which in the case of the present invention is the sequence  $r = 2^j$  where  $j \in \mathbb{Z}$ . The difference in frequency between consecutive octaves therefore varies by a factor of two.

Stephane Mallat formalized the relationship between wavelet transforms and multiresolution analysis by first defining a multiresolution space sequence  $\{V_j\}_{j \in \mathbb{Z}}$ , where  $V_j$  is the set of all possible approximated signals at resolution  $2^j$ . He then showed that an orthonormal basis for  $V_j$  can be constructed by  $\{\phi^j(x-2^{-j}n)\}_{n \in \mathbb{Z}}$ .  $\phi(x)$  is called the scaling function where for any  $j \in \mathbb{Z}$ ,  $\phi^j(x) = \sqrt{2^j} \phi(2^j x)$ . He then showed that a signal  $f(x)$  can be approximated at a resolution  $2^j$  by the set of samples:



- 17 -

$$S_j = \{\sqrt{2^j} \langle f, \phi_n^j \rangle\}_{n \in \mathbb{Z}} \quad (\text{equ. 6})$$

where  $\langle f, g \rangle = \int_{-\infty}^{\infty} f(x) g(x) dx$ , where  $f, g \in L^2(\mathbb{R})$ ,  
 the set of square integrable functions on  $\mathbb{R}$ . This is  
 equivalent to convolving the signal  $f(x)$  with the scaling  
 5 function  $\phi^j(-x)$  at a sampling rate of  $2^j$ . However, this  
 representation is highly redundant because  $V_j \subset V_{j+1}, j \in \mathbb{Z}$ .  
 It would be more efficient to generate a sequence of  
 multiresolution detail signals  $O_j$  which represents the  
 difference information between successive resolutions  
 10  $O_j \oplus V_j = V_{j+1}$  where  $O_j$  is orthogonal to  $V_j$ . Mallat proved that  
 there exists a function  $\Psi(x)$  called the wavelet where:

$$\psi^j(x) = \sqrt{2^j} \psi(2^j x) \quad (\text{equ. 7})$$

such that  $\{\Psi^j(x - 2^j n)\}_{n \in \mathbb{Z}}$  is an orthonormal basis of  $O_j$  and  
 $\{\Psi^j(x - 2^j n)\}, (j, n) \in \mathbb{Z}^2$ , is an orthonormal basis of  $L^2(\mathbb{R})$ .  
 15 The detail signal at resolution  $2^{j+1}$  is represented by the  
 set of data values:

$$N_j = \{\sqrt{2^j} \langle f, \psi_n^j \rangle\}_{n \in \mathbb{Z}} \quad (\text{equ. 8})$$

which is equivalent to convolving the signal  $f(x)$  with the  
 wavelet  $\Psi^j(-x)$  at a sampling rate of  $2^j$ .

20 Hence, the original signal  $f(x)$  can be completely  
 represented by the sets of data values  $(S_j, (N_j)_{J \leq j \leq -1})$ ,  
 where  $J < 0$  gives the number of octaves. This  
 representation in the form of data values is known as the  
 discrete wavelet decomposition. The  $S_j$  notation used by  
 25 Mallat refers to recursively low pass filter values of the  
 original signal.  $S_0$  corresponds to the original data  
 values  $D$ .  $S_1$  corresponds to the  $H$  data values from the  
 low pass filter.  $N_1$  corresponds to the  $G$  data values from  
 the high pass filter.  $S_2$  corresponds to the next low pass  
 30 filtered values from the previous  $H$  sub-band.  $N_2$   
 corresponds to the next high pass filtered values from the  
 previous  $H$  sub-band.

If the sampling patterns of the discrete windowed

- 18 -

Fourier transform and the discrete wavelet transform are compared while maintaining the spatial locality of the highest frequency sample for both transforms, then the efficiency of the discrete wavelet decomposition is revealed. The window Fourier transform produces a linear sampling grid, each data value being a constant spatial distance or a constant frequency away from its neighbor. The result is a heavy over-sampling of the lower frequencies. The wavelet transform, in contrast, samples each of its octave wide frequency bands at the minimum rate such that no redundant information is introduced into the discrete wavelet decomposition. The wavelet transform is able to achieve highly local spatial sampling at high frequencies by the use of octave wide frequency bands. At low frequencies, spectral locality takes precedence over spatial locality.

Figure 7 illustrates the spatial and spectral locality of a sequence of sampled data values. The box surrounding a data value represents the spatial and spectral locality of the data value. The regions of Figure 7 are presented for explanation purposes. In reality there is some overlap and aliasing between adjacent data values, the characteristics of which are determined by the particular wavelet function used.

Mallat showed the wavelet transform can be computed with a pyramid technique, where only two filters are used. Using this technique,  $S_j$  and  $N_j$  are calculated from  $S_{j+1}$ ,  $S_j$  being used as the input for the next octave of decomposition. A low pass filter  $H$ :

$$h(n) = \frac{1}{\sqrt{2}} \langle \phi_0^{-1}, \phi_n^0 \rangle \quad (\text{equ. 9})$$

Mallat showed that  $S_j$  can be calculated by convolving from  $S_{j+1}$  with  $H$  and keeping every other output (i.e. sub-sampling by a factor of 2).

A method for calculating  $N_j$  from  $S_{j+1}$  can also be derived. This method involves convolving  $S_{j+1}$  with a high

- 19 -

pass filter G and sub-sampling by a factor of 2. The high pass filter G is defined by the following coefficients:

$$g(n) = (-1)^{1-n} h(1-n) \quad (\text{equ. 10})$$

The relationship between the H and G filters results in a large saving when the filters are implemented in hardware.

Figures 8 and 9 illustrate that these two filters H and G form a complementary pair that split an input signal into two half band output signals. Both the high and the low pass outputs can be sub-sampled by a factor of two without corrupting the high frequency information because any aliasing introduced by the sub-sampling will be corrected in the reconstruction. There are the same number of filtered data values as there are original image data values.

The particular wavelet which is best in analyzing a signal under analysis is heavily dependent on the characteristics of the signal under analysis. The closer the wavelet resembles the features of the signal, the more efficient the wavelet representation of the signal will be. In addition, reconstruction errors introduced by quantization resemble the wavelet. Typically, the amount of aliasing varies with spatial support (the number of coefficients of the wavelet filters). Long wavelets can be constructed such that aliasing between adjacent octave bands is minimized. However, the spatial equivalent of aliasing, overlap, increases with filter length. Conversely, short wavelets have little or no overlap spatially but exhibit large amounts of aliasing in the frequency domain. To properly determine the suitability of a wavelet for a particular application, these factors of size and shape must be considered.

To apply the wavelet transform to image processing, the present invention employs a particular wavelet called the four coefficient Daubechies wavelet. Because the four

- 20 -

coefficient Daubechies wavelet has only four coefficients, it is very short. This is well-suited for analyzing important image features such as object edges. Edges by definition are spatially local discontinuities. Edges often consist of a wide spectral range which, when filtered through a high pass filter, give rise to relatively larger filtered outputs only when the analysis filter coincides with the edge. When the analysis filter does not coincide with the edge, relatively smaller filtered outputs are output by the filter. The shorter the analysis filter used, the more finely the spatial position of the edge is resolved. Longer filters produce more of the relatively larger data values to represent an edge. The shortness of the filter also makes the transform calculation relatively inexpensive to implement compared with that of longer filters or image transformations such as the Fourier or discrete cosine transforms. The four coefficient Daubechies wavelet was selected for use only after a careful analysis of both its spatial and aliasing characteristics. Longer wavelets such as the six coefficient Daubechies wavelet could, however, also be used if a more complex implementation were acceptable. Short filters such as the two coefficients Haar wavelet could also be used if the attendant high levels of noise were acceptable.

The true coefficients of the four coefficient Daubechies wavelet are:

$$a = \frac{1+\sqrt{3}}{8}, b = \frac{3+\sqrt{3}}{8}, c = \frac{3-\sqrt{3}}{8}, d = \frac{-1+\sqrt{3}}{8} \quad (\text{equ. 11})$$

The low pass four coefficient Daubechies digital filter is given by:

$$H\left(\frac{x}{2}\right) = aD(x-1) + bD(x) + cD(x+1) - dD(x+2) \quad (\text{equ. 12})$$

The high pass four coefficient Daubechies digital filter is given by:

- 21 -

$$G\left(\frac{x}{2}\right) = dD(x-1) + cD(x) - bD(x+1) + aD(x+2) \quad (\text{equ. 13})$$

In equations 12 and 13,  $D(x-1)$ ,  $D(x)$ ,  $D(x+1)$  and  $D(x+2)$  are four consecutive data values.  $H\left(\frac{x}{2}\right)$  and  $G\left(\frac{x}{2}\right)$  are true perfect reconstruction filters, i.e. the inverse transform  
 5 perfectly reconstructs the original data. For example, when the filters operate on data values  $D(1)$ ,  $D(2)$ ,  $D(3)$  and  $D(4)$ , outputs  $H(1)$  and  $G(1)$  are generated. Index  $x$  in this case would be 2. Due to the presence of the  $\frac{x}{2}$  as the index for the filters  $H$  and  $G$ , the values of  $x$  can  
 10 only be even integers.

To simplify the computational complexity involved in performing the transformation on real data, the coefficients of the four coefficient Daubechies filter which are non-rational numbers are converted into rational  
 15 numbers which can be efficiently implemented in software or hardware. Floating point coefficients are not used because performing floating point arithmetic is time consuming and expensive when implemented in software or hardware.

20 To convert the four Daubechies coefficients for implementation, three relationships of the coefficients  $a$ ,  $b$ ,  $c$  and  $d$  are important. In order for the  $H$  filter to have unity gain, the following equation must hold:

$$a + b + c - d = 1 \quad (\text{equ. 14})$$

25 In order for the  $G$  filter to reject all zero frequency components in the input data values, the following equation must hold:

$$a - b + c + d = 0 \quad (\text{equ. 15})$$

In order for the resulting  $H$  and  $G$  filters to be able to  
 30 generate a decomposition which is perfectly reconstructible into the original image data the following equation must hold:

- 22 -

$$ac - bd = 0 \quad (\text{equ. 16})$$

True four coefficient Daubechies filters satisfy the above three equations 14, 15, and 16. However, when the coefficients of the true low and high pass four  
 5 coefficient Daubechies filters are converted for implementation, at least one of the three relationships must be broken. In the preferred embodiment, unity gain and the rejection of all zero frequency components are maintained. It is the third relationship of equation 16  
 10 that is compromised. Perfect reconstruction is compromised because the process of compressing image data itself inherently introduces some noise due to the tree coding and quantization of the present invention. The reconstructed data values therefore necessarily involve  
 15 noise when a real-world image is compressed and then reconstructed. We define filters which satisfy equations 14, and 15 and approximately satisfy equation 16, quasi-perfect reconstruction filters.

Table 2 illustrates a process of converting the  
 20 coefficients a, b, c and d for implementation.

$$a = \frac{1+\sqrt{3}}{8} = .3415(32) = 10.92 = \frac{11}{32}$$

$$b = \frac{3+\sqrt{3}}{8} = .5915(32) = 18.92 = \frac{19}{32}$$

$$c = \frac{3-\sqrt{3}}{8} = .1585(32) = 5.072 = \frac{5}{32}$$
 25 
$$d = \frac{-1+\sqrt{3}}{8} = .0915(32) = 2.928 = \frac{3}{32}$$

Table 2

The true four coefficient Daubechies filter coefficients are listed in the left hand column of Table 2. In the next column to the right, the true coefficients are shown  
 30 rounded to four places beyond the decimal point. The

- 23 -

rounded coefficients are scaled by a factor of 32 to achieve the values in the next column to the right. From each value in the third column, an integer value is selected. Which integers are selected has a dramatic effect on the complexity of the software or hardware which compresses the image data. The selected integers are divided by 32 so that the scaling by 32 shown in the second column does not change the values of the resulting converted coefficients.

10 In selecting the integers for the fourth column, the relationship of the three equations 14, 15 and 16 are observed. In the case of  $a = 11/32$ ,  $b = 19/32$ ,  $c = 5/32$  and  $d = 3/32$ , the relationships  $a+b+c-d=1$  and  $a-b+c+d=0$  both are maintained. Because the converted coefficients  
15 in the rightmost column of Table 2 are quite close to the true coefficient values in the leftmost column, the resulting four coefficient filters based on coefficients  $a$ ,  $b$ ,  $c$  and  $d$  allow near perfect reconstruction. On a typical 640 by 480 image, the error between the original  
20 and reconstructed data values after forward and then inverse transformation has been experimentally verified to exceed 50 dB.

The resulting high pass four coefficient quasi-Daubechies filter is:

$$25 \quad H\left(\frac{x}{2}\right) = \frac{11}{32}D(x-1) + \frac{19}{32}D(x) + \frac{5}{32}D(x+1) - \frac{1}{32}D(x+2) \text{ (equ. 17)}$$

The resulting low pass four coefficient quasi-Daubechies filter is:

$$G\left(\frac{x}{2}\right) = \frac{3}{32}D(x-1) + \frac{5}{32}D(x) - \frac{19}{32}D(x+1) + \frac{11}{32}D(x+2) \text{ (equ. 18)}$$

Because the high and low pass four coefficient quasi-  
30 Daubechies filters satisfy equations 14 and 15 and approximately satisfy equation 16, the high and low pass four coefficient quasi-Daubechies filters are quasi-perfect reconstruction filters.

- 24 -

Note that the particular converted coefficients of the quasi-Daubechies filters of equations 17 and 18 result in significant computational simplicity when implementation is either software and/or hardware.

5 Multiplications and divisions by factors of two such as multiplications and divisions by 32 are relatively simple to perform. In either hardware or software, a multiplication by 2 or a division by 2 can be realized by a shift. Because the data values being operated on by the  
10 digital filter already exist in storage when the filter is implemented in a typical system, the shifting of this data after the data has been read from storage requires little additional computational overhead. Similarly, changing the sign of a quantity involves little additional  
15 overhead. In contrast, multiplication and division by numbers that are not a power of 2 require significant overhead to implement in both software and hardware. The selection of the coefficients in equations 17 and 18 allows  $H(x)$  and  $G(x)$  to be calculated with only additions  
20 and shifts. In other words, all multiplications and divisions are performed without multiplying or dividing by a number which is not a power of 2. Due to the digital filter sequencing through the data values, pipelining techniques can also be employed to reduce the number of  
25 adds further by using the sums or differences computed when the filters were operating on prior data values.

Moreover, the magnitudes of the inverse transform filter coefficients are the same as those of the transform filter itself. As described further below, only the order  
30 and signs of the coefficients are changed. This reduces the effective number of multiplications which must be performed by a factor of two when the same hardware or software implementation is to be used for both the forward and inverse transform. The fact that the signal being  
35 analyzed is being sub-sampled reduces the number of additions by a factor of two because summations are required only on the reading of every other sample. The



- 25 -

effective number of filters is therefore only one to both transform the data into the decomposition and to inverse transform the decomposition back into the image data.

#### IMAGE COMPRESSION AND DECOMPRESSION USING THE 5 QUASI-PERFECT RECONSTRUCTION TRANSFORM

Color images can be decomposed by treating each Red-Green-Blue (or more usually each Luminance-Chrominance-Chrominance channel) as a separate image. In the case of Luminance-Chrominance-Chrominance (YUV or YIQ) images the  
10 chrominance components may already have been sub-sampled. It may be desirable therefore, to transform the chrominance channels through a different number of octaves than the luminance channel. The eye is less sensitive to chrominance at high spatial frequency and therefore these  
15 channels can be sub-sampled without loss of perceived quality in the output image. Typically these chrominance channels are sub-sampled by a factor of two in each dimension so that they together take only 50 percent of the bandwidth of the luminance channel. When implementing  
20 an image compression technique, the chrominance channels are usually treated the same way as the luminance channel. The compression technique is applied to the three channels independently. This approach is reasonable except in the special cases where very high compression ratios and very  
25 high quality output are required. To squeeze the last remaining bits from a compression technique or to achieve more exacting quality criteria, knowledge of how the chrominance rather than luminance values are perceived by the human visual system can be applied to improve the  
30 performance of the compression technique by better matching it with the human visual system.

Figure 10 is an illustration of a two dimensional matrix of data values. There are rows of data values extending in the horizontal dimension and there are  
35 columns of data values extending in the vertical dimension. Each of the data values may, for example, be

an 8-bit binary number of image pixel information such as the luminance value of a pixel. The data values of Figure 10 represent an image of a black box 100 on a white background 101.

5 To transform the data values of the image of Figure 10 in accordance with one aspect of the present invention, a high pass four coefficient quasi-Daubechies digital filter is run across the data values horizontally, row by row, to result in a block 102 of high pass output values G  
10 shown in Figure 11. The width of the block 102 of high pass output values in Figure 11 is half the width of the original matrix of data values in Figure 10 because the high pass four coefficient quasi-Daubechies digital filter is moved across the rows of the data values by twos.  
15 Because only one additional digital filter output is generated for each additional two data values processed by the digital filter, the data values of Figure 10 are said to have been sub-sampled by a factor of two.

Figure 12 illustrates the sub-sampling performed by  
20 the high pass digital filter. High pass output  $G_1$  is generated by the high pass digital filter from data values  $D_1$ ,  $D_2$ ,  $D_3$  and  $D_4$ . The next high pass output generated, output  $G_2$ , is generated by the high pass digital filter from data values  $D_3$ ,  $D_4$ ,  $D_5$  and  $D_6$ . The high pass digital  
25 filter therefore moves two data values to the right for each additional high pass output generated.

A low pass four coefficient quasi-Daubechies digital filter is also run across the data values horizontally, row by row, to generate H block 103 of the low pass  
30 outputs shown in Figure 11. This block 103 is generated by sub-sampling the data values of Figure 10 in the same way the block 102 was generated. The H and G notation for the low and high pass filter outputs respectively is used as opposed to the  $S_j$  and  $O_j$  notation used by Mallat to  
35 simplify the description of the two-dimensional wavelet transform.

Figure 13 illustrates the sub-sampling of the low

- 27 -

pass digital filter. Low pass output  $H_1$  is generated by the low pass digital filter from data values  $D_1$ ,  $D_2$ ,  $D_3$  and  $D_4$ . The next low pass output generated, output  $H_2$ , is generated by the low pass digital filter from data values  $D_3$ ,  $D_4$ ,  $D_5$  and  $D_6$ . The low pass digital filter therefore moves two data values to the right for each additional low pass output generated.

After the high and low pass four coefficient quasi-Daubechies digital filters have generated blocks 102 and 103, the high and low pass four coefficient quasi-Daubechies digital filters are run down the columns of blocks 102 and 103. The values in blocks 102 and 103 are therefore sub-sampled again. The high pass four coefficient quasi-Daubechies digital filter generates blocks 104 and 105. The low pass four coefficient quasi-Daubechies digital filter generates blocks 106 and 107. The resulting four blocks 104-107 are shown in Figure 14. Block 106 is the low frequency component of the original image data. Blocks 107, 104 and 105 comprise the high frequency component of the original image data. Block 106 is denoted block HH. Block 107 is denoted block GH. Block 104 is denoted block HG. Block 105 is denoted block GG.

This process of running the high and low pass four coefficient quasi-Daubechies digital filters across data values both horizontally and vertically to decompose data values into high and low frequency components is then repeated using the data values of the HH block 106 as input data values. The result is shown in Figure 15. Block 108 is the low frequency component and is denoted block HHHH. Blocks 109, 110 and 111 comprise octave 1 of the high frequency component and are denoted HHHG, HHGH, HHGG, respectively. Blocks HG, GH and GG comprise octave 0 of the high frequency component.

Although this recursive decomposition process is only repeated twice to produce high pass component octaves 0 and 1 in the example illustrated in connection with

- 28 -

Figures 10-15, other numbers of recursive decomposition steps are possible. Recursively decomposing the original data values into octaves 0, 1, 2 and 3 has been found to result in satisfactory results for most still image data 5 and recursively decomposing the original data into octaves 0, 1, and 2 has been found to result in satisfactory results for most video image data.

Moreover, the horizontal and subsequent vertical operation of the high and low pass filters can also be 10 reversed. The horizontal and subsequent vertical sequence is explained in connection with this example merely for instructional purposes. The filters can be moved in the vertical direction and then in the horizontal direction. Alternatively, other sequences and dimensions of moving 15 the digital filters through the data values to be processed is possible.

It is also to be understood that if the original image data values are initially arrayed in a two dimensional block as shown in Figure 10, then the 20 processing of the original image data values by the high and low pass filters would not necessarily result in the HH values being located all in an upper right hand quadrant as is shown in Figure 14. To the contrary, depending on where the generated HH values are written, 25 the HH data values can be spread throughout a block. The locations of the HH values are, however, determinable. The HH values are merely illustrated in Figure 14 as being located all in the upper lefthand quadrant for ease of illustration and explanation.

30 Figure 16 is an illustration showing one possible twelve-by-twelve organization of original image data values in a two dimensional array. Figure 16 corresponds with Figure 10. The location in the array of each data value is determined by a row number and column number. A 35 row number and column number of a data value may, for example, correspond with a row address and column address in an addressed storage medium. This addressed storage

- 29 -

medium may, for example, be a semiconductor memory, a magnetic storage medium, or an optical storage medium. The row and column may, for example, also correspond with a pixel location including a location of a pixel on a cathode-ray tube or on a flat panel display.

Figure 17 is an illustration showing the state of the two dimensional array after a one octave decomposition. The HH low frequency components are dispersed throughout the two dimensional array as are the HG values, the GH values, and the GG values. The subscripts attached to the various data values in Figure 17 denote the row and column location of the particular data value as represented in the arrangement illustrated in Figure 14.  $HH_{00}$ ,  $HH_{01}$ ,  $HH_{02}$ ,  $HH_{03}$ ,  $HH_{04}$  and  $HH_{05}$ , for example, are six data values which correspond with the top row of data values in HH block 106 of Figure 14.  $HH_{00}$ ,  $HH_{10}$ ,  $HH_{20}$ ,  $HH_{30}$ ,  $HH_{40}$  and  $HH_{50}$ , for example, are six data values which correspond with the leftmost column of data values in HH block 106 of Figure 14.

When the high and the low pass forward transform digital filters operate on the four data values  $D_{01}$ ,  $D_{02}$ ,  $D_{03}$  and  $D_{04}$  of Figure 16, the output of the low pass forward transform digital filter is written to location row 0 column 2 and the output of the high pass forward transform digital filter is written to location row 0 column 3. Next, the high and low pass forward transform digital filters are moved two locations to the right to operate on the data values  $D_{03}$ ,  $D_{04}$ ,  $D_{05}$  and  $D_{06}$ . The outputs of the low and high pass forward transform digital filters are written to locations row 0 column 4 and row 0 column 5, respectively. Accordingly, the outputs of the low and high frequency forward transform digital filters are output from the filters to form an interleaved sequence of low and high frequency component data values which overwrite the rows of data values in the two dimensional array.

Similarly, when the low and high pass forward

- 30 -

transform digital filters operate on the four data values at locations column 0, rows 1 through 4, the output of the low pass forward transform digital filter is written to location column 0 row 2. The output of the high pass forward transform digital filter is written to location column 0 row 3. Next the low and high pass forward transform digital filters are moved two locations downward to operate on the data values at locations column 0, rows 3 through 6. The outputs of the low and high pass forward transform digital filters are written to locations column 0 row 4 and column 0 row 5, respectively. Again, the outputs of the low and high pass forward transform digital filters are output from the filters in an interleaved fashion to overwrite the columns of the two dimensional array.

Figure 18 is an illustration showing the state of the two dimensional array after a second octave decomposition. The HHHH low frequency components corresponding which block 108 of Figure 15 as well as the octave 1 high frequency components HHGH, HHHG and HHGG are dispersed throughout the two dimensional array. When the HH values  $HH_{01}$ ,  $HH_{02}$ ,  $HH_{03}$  and  $HH_{04}$  of Figure 17 are processed by the low and high pass forward transform digital filters, the outputs are written to locations row 0 column 4 and row 0 column 6, respectively. Similarly, when the values at locations column 0, rows 2, 4, 6 and 8 are processed by the low and high pass forward transform digital filters, the results are written to locations column 0 row 4 and column 0 row 6, respectively. The data values in Figure 18 are referred to as transformed data values. The transformed data values are said to comprise the decomposition of the original image values.

This method of reading data values, transforming the data values, and writing back the output of the filters is easily expanded to a two dimensional array of a very large size. Only a relatively small number of locations is shown in the two dimensional array of Figures 10-18 for

- 31 -

ease of explanation and clarity of illustration.

The transformed data values are reconverted back into image data values substantially equal to the original image data by carrying out a reverse process. This reverse process is called the inverse transform. Due to the interleaved nature of the decomposition data in Figure 18, the two digital filters used to perform the inverse transform are called interleaved inverse transform digital filters. Odd data values are determined by an odd interleaved inverse digital filter O. Even data values are determined by the even interleaved inverse transform digital filter E.

The odd and even interleaved inverse digital filters can be determined from the low and high pass forward transform digital filters used in the forward transform because the coefficients of the odd interleaved inverse transform digital filters are related to the coefficients of the low and high pass forward transform filters. To determine the coefficients of the odd and even interleaved inverse transform digital filters, the coefficients of the low and high pass forward transform digital filters are reversed. Where the first, second, third and fourth coefficients of the low pass forward transform digital filter H of equation 17 are denoted a, b, c and -d, the first, second, third and fourth coefficients of a reversed filter H\* are denoted -d, c, b and a. Similarly, where the first, second, third and fourth coefficients of the high pass forward transform digital filter G of equation 18 are denoted d, c, -b and a, the first, second, third and fourth coefficients of a reverse filter G\* are denoted a, -b, c and d.

The first through the fourth coefficients of the even interleaved inverse transform digital filter E are the first coefficient of H\*, the first coefficient of G\*, the third coefficient of H\*, and the third coefficient of G\*. The coefficients of the even interleaved inverse transform digital filter E therefore are -d, a, b and c. In the

- 32 -

case of the low and high pass four coefficient quasi-Daubechies filters used in the transform where  $a=\frac{11}{32}$ ,  $b=\frac{19}{32}$ ,  $c=\frac{5}{32}$  and  $d=\frac{3}{32}$ , the even interleaved inverse transform digital filter is:

$$5 \quad \frac{D(2x)}{2} = -\frac{3}{32}H(x-1) + \frac{11}{32}G(x-1) + \frac{19}{32}H(x) + \frac{5}{32}G(x) \text{ (equ. 19)}$$

where  $H(x-1)$ ,  $G(x-1)$ ,  $H(x)$  and  $G(x)$  are transformed data values of a decomposition to be inverse transformed.

The first through the fourth coefficients of the odd interleaved inverse transform digital filter 0 are the  
 10 second coefficient of  $H^*$ , the second coefficient of  $G^*$ , the fourth coefficient of  $H^*$ , and the fourth coefficient of  $G^*$ . The coefficients of the odd interleaved inverse transform digital filter 0 therefore are  $c$ ,  $-b$ ,  $a$  and  $d$ . In the case of the low and high pass four coefficient  
 15 quasi-Daubechies filters used in the transform where  $a=\frac{11}{32}$ ,  $b=\frac{19}{32}$ ,  $c=\frac{5}{32}$  and  $d=\frac{3}{32}$ , the odd interleaved inverse transform digital filter is:

$$\frac{D(2x-1)}{2} = \frac{5}{32}H(x-1) - \frac{19}{32}G(x-1) + \frac{11}{32}H(x) + \frac{3}{32}G(x) \text{ (equ. 20)}$$

where  $H(x-1)$ ,  $G(x-1)$ ,  $H(x)$  and  $G(x)$  are data values of a  
 20 decomposition to be inverse transformed.

To inverse transform the transformed data values of Figure 18 into the data values of Figure 17, the HHHG, HHGG, HHGH and data values are inverse transformed with the HHHH data values to create the HH data values of  
 25 Figure 17. This process corresponds with the inverse transformation of HHHG block 109, HHGH block 110, HHGG block 111, and HHHH block 108 of Figure 15 back into the HH data values of block 106 of Figure 14. The HG, GH and GG data values of Figure 18 are therefore not processed by  
 30 the odd and even interleaved inverse transform digital filters in this step of the inverse transform.



- 33 -

In Figure 18, the odd interleaved inverse transform digital filter processes the values in locations column 0, rows 0, 2, 4 and 6 to generate the odd data value at location column 0 row 2. The even interleaved inverse transform digital filter data also processes the values in the same locations to generate the even data value at location column 0 row 4. The odd and even interleaved inverse transform digital filters then process the values in locations column 0, rows 4, 6, 8 and A to generate the values at locations column 0 row 6 and column 0 row 8, respectively. Each of the six columns 0, 2, 6, 4, 8, and A of the values of Figure 18 are processed by the odd and even interleaved inverse transform digital filters in accordance with this process.

15 The various locations are then processed again by the odd and even interleaved inverse transform digital filters, this time in the horizontal direction. The odd and even interleaved inverse transform digital filters process the values at locations row 0 columns 0, 2, 4 and 6 to generate the values at locations row 0 column 2 and row 0 column 4, respectively. The odd and even interleaved inverse transform digital filters process the values at locations row 0 columns 4, 6, 8 and A to generate the values at locations row 0 column 6 and row 0 column 8, respectively. Each of the six rows 0, 2, 4 and 8 and of values are processed by the even and odd interleaved inverse transform digital filters in accordance with this process. The result is the reconstruction shown in Figure 17.

30 The even and odd interleaved inverse transform digital filters then process the values shown in Figure 17 into the data values shown in Figure 16. This inverse transformation corresponds with the transformation of the HH block 106, the HG block 104, the GH block 107 and the GG block 105 of Figure 14 into the single block of data value of Figure 10. The resulting reconstructed data values of Figure 16 are substantially equal to the original image

- 34 -

data values.

Note, however, that in the forward transform of the data values of Figure 16 into the data values of Figure 17 that the low and high pass four coefficient quasi-Daubechies digital filters cannot generate all the data values of Figure 17 due to the digital filters requiring data values which are not in the twelve by twelve matrix of data values of Figure 16. These additional data values are said to be beyond the "boundary" of the data values to be transformed.

Figure 19 illustrates the high pass four coefficient quasi-Daubechies digital filter operating over the boundary to generate the  $G_0$  data value. In order to generate the  $G_0$  data value in the same fashion that the other high frequency G data values are generated, the high pass digital filter would require data values  $D_{-1}$ ,  $D_0$ ,  $D_1$  and  $D_2$  as inputs. Data value  $D_{-1}$ , however, does not exist. Similarly, Figure 20 illustrates the low pass four coefficient quasi-Daubechies digital filter operating over the boundary to generate the  $H_0$  data value. In order to generate the  $H_0$  data value in the same fashion that the other low frequency H data values are generated, the low pass digital filter would require data values  $D_{-1}$ ,  $D_0$ ,  $D_1$  and  $D_2$  as inputs. Data value  $D_{-1}$ , however, does not exist.

The present invention solves this boundary problem by using additional quasi-Daubechies digital filters to generate the data values adjacent the boundary that would otherwise require the use of data values outside the boundary. There is a high pass "start" quasi-Daubechies forward transform digital filter  $G_s$ , which is used to generate the first high pass output  $G_0$ . There is a low pass "start" quasi-Daubechies forward transform digital filter  $H_s$ , which is used to generate the first low pass output  $H_0$ . These start quasi-Daubechies forward transform digital filters are three coefficient filters rather than four coefficient filters and therefore require only three data values in order to generate an output. This allows

- 35 -

the start quasi-Daubechies forward transform digital filters to operate at the boundary and to generate the first forward transform data values without extending over the boundary.

5        Figure 21 illustrates the low and high pass start quasi-Daubechies forward transform digital filters operating at the starting boundary of image data values  $D_0$  through  $D_B$ . The three coefficient low and high pass start quasi-Daubechies forward transform digital filters operate  
10 on data values  $D_0$ ,  $D_1$  and  $D_2$  to generate outputs  $H_0$  and  $G_0$ , respectively.  $H_1$ ,  $H_2$ ,  $H_3$  and  $H_4$ , on the other hand, are generated by the low pass four coefficient quasi-Daubechies forward transform digital filter and  $G_1$ ,  $G_2$ ,  $G_3$  and  $G_4$  are generated by the high pass four coefficient  
15 quasi-Daubechies forward transform digital filter.

A similar boundary problem is encountered at the end of the data values such as at the end of the data values of a row or a column of a two-dimensional array. If the low and high pass four coefficient quasi-Daubechies  
20 filters G and H are used at the boundary in the same fashion that they are in the middle of the data values, then the four coefficient quasi-Daubechies forward transform digital filters would have to extend over the end boundary to generate the last low and high pass  
25 outputs, respectively.

The present invention solves this boundary problem by using additional quasi-Daubechies forward transform digital filters in order to generate the transformed data values adjacent the end boundary that would otherwise  
30 require the use of data outside the boundary. There is a low pass "end" quasi-Daubechies forward transform digital filter  $H_e$  which is used to generate the last low pass output. There is a high pass "end" quasi-Daubechies forward transform digital filter  $G_e$  which is used to  
35 generate the last high pass output. These two end quasi-Daubechies forward transform digital filters are three coefficient filters rather than four coefficient filters

- 36 -

and therefore require only three data values in order to generate an output. This allows the end quasi-Daubechies forward transform digital filters to operate at the boundary and to generate the last transform data values  
5 without extending over the boundary.

Figure 21 illustrates two low and high pass end quasi-Daubechies forward transform digital filters operating at the end boundary of the image data. These three coefficient low and high pass end quasi-Daubechies  
10 forward transform digital filters operate on data values  $D_9$ ,  $D_A$  and  $D_B$  to generate outputs  $H_1$  and  $G_1$ , respectively. This process of using the appropriate start or end low or high pass filter is used in performing the transformation at the beginning and at the end of each row and column of  
15 the data values to be transformed.

The form of the low pass start quasi-Daubechies forward transform digital filter  $H_1$  is determined by selecting a value of a hypothetical data value  $D_1$  which would be outside the boundary and then determining the  
20 value of the four coefficient low pass quasi-Daubechies forward transform filter if that four coefficient forward transform filter were to extend beyond the boundary to the hypothetical data value in such a way as would be necessary to generate the first low pass output  $H_0$ . This  
25 hypothetical data value  $D_1$  outside the boundary can be chosen to have one of multiple different values. In some embodiments, the hypothetical data value  $D_1$  has a value equal to the data value  $D_0$  at the boundary. In some embodiments, the hypothetical data value  $D_1$  is set to zero  
30 regardless of the data value  $D_0$ . The three coefficient low pass start quasi-Daubechies forward transform digital filter  $H_1$  therefore has the form:

$$H_0 = K1 + bD_0 + cD_1 - dD_2 \quad (\text{equ. 21})$$

where  $K1$  is equal to the product  $aD_1$ , where  $D_0$  is the first  
35 data value at the start boundary at the start of a

- 37 -

sequence of data values, and where a, b, c and d are the four coefficients of the four coefficient low pass quasi-Daubechies forward transform digital filter. If, for example, hypothetical data value  $D_1$  is chosen to be equal to the data value  $D_0$  adjacent but within the boundary, then  $K1=aD_0$  where  $a = 11/32$  and  $D_0$  is the data value adjacent the boundary, equation 21 then becomes:

$$H_0 = (a+b)D_0 + cD_1 - dD_2 \quad (\text{equ. 22})$$

The form of the high pass start quasi-Daubechies forward transform digital filter  $G$ , is determined by the same process using the same hypothetical data value  $D_1$ . The high pass start quasi-Daubechies forward transform digital filter  $G$ , therefore has the form:

$$G_0 = K2 + cD_0 - bD_1 + aD_2 \quad (\text{equ. 23})$$

where  $K2$  is equal to the product  $dD_1$ , where  $D_0$  is the first data value at the boundary at the start of a sequence of data values, and where a, b, c and d are the four coefficients of the four coefficient high pass quasi-Daubechies forward transform digital filter. If hypothetical data value  $D_1$  is chosen to be equal to  $D_0$ , then equation 23 becomes:

$$G_0 = (d + c)D_0 - bD_1 + aD_2 \quad (\text{equ. 24})$$

The form of the low pass end quasi-Daubechies forward transform digital filter  $H$ , is determined in a similar way to the way the low pass start quasi-Daubechies forward transform digital filter is determined. A value of a data value  $D_c$  is selected which would be outside the boundary. The value of the four coefficient low pass quasi-Daubechies forward transform digital filter is then determined as if that four coefficient filter were to extend beyond the boundary to data value  $D_c$  in such a way

- 38 -

as to generate the last low pass output  $H_5$ . The three coefficient low pass end quasi-Daubechies forward transform digital filter therefore has the form:

$$H_5 = aD_9 + bD_A + cD_B - K3 \quad (\text{equ. 25})$$

5 where  $K3$  is equal to the product  $dD_C$ , where  $D_B$  is the last data value of a sequence of data values to be transformed, and where  $a$ ,  $b$ ,  $c$  and  $d$  are the four coefficients of the four coefficient low pass quasi-Daubechies filter.  $D_B$  is the last data value in the particular sequence of data  
10 values of this example and is adjacent the end boundary. In the case where the hypothetical data value  $D_C$  is chosen to be equal to the data value  $D_B$  adjacent but within the end boundary, then  $K3=dD_B$  and equation 25 becomes:

$$H_5 = aD_9 + bD_A + (c-d)D_B \quad (\text{equ. 26})$$

15 The form of the high pass end quasi-Daubechies forward transform digital filter  $G_5$  is determined by the same process using the same data value  $D_C$ . The three coefficient high pass end quasi-Daubechies forward transform digital filter therefore has the form:

$$20 \quad G_5 = dD_9 + cD_A - bD_B + K4 \quad (\text{equ. 27})$$

where  $K4$  is equal to the product  $aD_C$ , where  $D_B$  is the last data value in this particular sequence of data values to be transformed, and where  $a$ ,  $b$ ,  $c$  and  $d$  are the four coefficients of the four coefficient high pass quasi-  
25 Daubechies forward transform digital filter.  $D_B$  is adjacent the end boundary. If hypothetical data value  $D_C$  is chosen to be equal to  $D_B$ , then equation 27 becomes:

$$G_5 = dD_9 + cD_A + (-b+a)D_B \quad (\text{equ. 28})$$

It is to be understood that the specific low and high

- 39 -

pass end quasi-Daubechies forward transform digital filters are given above for the case of data values  $D_0$  through  $D_B$  of Figure 21 and are presented merely to illustrate one way in which the start and end digital filters may be determined. In the event quasi-Daubechies filters are not used for the low and high pass forward transform digital filters, the same process of selecting a hypothetical data value or values outside the boundary and then determining the value of a filter as if the filter were to extend beyond the boundary can be used. In some embodiments, multiple hypothetical data values may be selected which would all be required by the digital filters operating on the inside area of the data values in order to produce an output at the boundary. This boundary technique is therefore extendable to various types of digital filters and to digital filters having numbers of coefficients other than four.

As revealed by Figure 22, not only does the forward transformation of data values at the boundary involve a boundary problem, but the inverse transformation of the transformed data values back into original image data values also involves a boundary problem. In the present example where four coefficient quasi-Daubechies filters are used to forward transform non-boundary data values, the inverse transform involves an odd inverse transform digital filter as well as an even inverse transform digital filter. Each of the odd and even filters has four coefficients. The even and odd reconstruction filters alternately generate a sequence of inverse transformed data values.

In Figure 22, the data values to be transformed are denoted  $H_0, G_0 \dots H_4, G_4, H_5, G_5$ . Where the forward transform processes the rows first and then the columns, the inverse transform processes the columns first and then the rows. Figure 22 therefore shows a column of transferred data values being processed in a first step of the inverse transform. Both the forward and the inverse

- 40 -

transforms in the described example, however, process the columns in a downward direction and process the rows in a left-right direction.

In Figure 22, the inverse transformed data values reconstructed by the inverse transform digital filters are denoted  $D_0, D_1, D_2, D_3 \dots D_B$ . The odd inverse transform digital filter outputs are shown on the left and the even inverse transform digital filter outputs are shown on the right.

At the beginning of the sequence of data values  $H_0, G_0, H_1, G_1 \dots H_5$  and  $G_5$  to be inverse transformed, the four coefficient odd and even inverse transform digital filters determine the values of reconstructed data values  $D_1$  and  $D_2$  using values  $H_0, G_0, H_1$  and  $G_1$ , respectively. Reconstructed data value  $D_0$ , however, cannot be reconstructed from the four coefficient even inverse transform digital filter without the four coefficient even inverse transform digital filter extending beyond the boundary. If the four coefficient even inverse transform filter were to be shifted two data values upward so that it could generate data value  $D_0$ , then the even four coefficient inverse transform digital filter would require two additional data values to be transformed, data values  $G_{-1}$  and  $H_{-1}$ .  $H_0$  is, however, the first data value within the boundary and is located adjacent the boundary.

To avoid the even four coefficient inverse transform digital filter extending beyond the boundary, a two coefficient inverse transform digital filter is used:

$$D_0 = 4[(b-a)H_0 + (c-d)G_0] \quad (\text{equ. 29})$$

in the case where  $K1 = aD_0$  and  $K2 = dD_0$ .  $D_0$  is the first data value and  $H_0$  is the data value to be inverse transformed adjacent the start boundary. This even start inverse transform digital filter has the form of the four coefficient even inverse transform digital filter except that the  $G_{-1}$  data value outside the boundary is chosen to



- 41 -

be equal to  $H_0$ , and the  $H_{-1}$  data value outside the boundary is chosen to be equal to  $G_0$ . The even start inverse transform digital filter therefore determines  $D_0$  as a function of only  $H_0$  and  $G_0$  rather than as a function of  $H_{-1}$ ,  $G_{-1}$ ,  $H_0$  and  $G_0$ .

Similarly, a two coefficient odd end inverse transform digital filter is used to avoid the four coefficient odd inverse transform digital filter from extending beyond the end boundary at the other boundary of a sequence of data values to be inverse transformed. The two coefficient odd end inverse transform digital filter used is:

$$D_B = 4[(c+d)H_5 - (a+b)G_5] \quad (\text{equ. 30})$$

in the case where  $K4 = aD_B$  and  $K3 = dD_B$ .  $D_B$  is the data value to be determined and  $G_5$  is the data value to be inverse transformed adjacent the end boundary. This odd end inverse transform digital filter has the form of the four coefficient odd inverse transform digital filter except that the  $H_6$  data value outside the boundary is chosen to be equal to  $G_5$  and the  $G_6$  data value outside the boundary is chosen to be equal to  $H_5$ . The odd end inverse transform digital filter therefore determines  $D_B$  as a function of only  $H_5$  and  $G_5$  rather than as a function of  $H_5$ ,  $G_5$ ,  $H_6$  and  $G_6$ .

It is to be understood that the particular even start and odd end inverse transform digital filters used in this embodiment are presented for illustrative purposes only. Where there is a different number of data values to be inverse transformed in a sequence of data values, an even end inverse transform digital filter may be used at the boundary rather than the odd end inverse transform digital filter. The even end inverse transform digital filter is an even inverse transform digital filter modified in accordance with the above process to have fewer coefficients than the even inverse transform digital

- 42 -

filter operating on the inner data values. Where filters other than quasi-Daubechies inverse transform digital filters are used, start and end inverse transform digital filters can be generated from the actual even and odd  
 5 inverse transform digital filters used to inverse transform data values which are not adjacent to a boundary. In the inverse transform, the start inverse transform digital filter processes the start of the transformed data values at the start boundary, then the  
 10 four coefficient inverse transform digital filters process the non-boundary transformed data values, and then the end inverse transform digital filter processes the end of the transformed data values.

The true Daubechies filter coefficients a, b, c and d  
 15 fulfil some simple relationships which show that the inverse transform digital filters correctly reconstruct non-boundary original image data values.

$$a+c = \frac{1}{2}, \quad b-d = \frac{1}{2}, \quad c+d = \frac{1}{4}, \quad b-a = \frac{1}{4} \quad (\text{equ. 31})$$

and the second order equations:

$$20 \quad ac-bd = 0, \quad a^2+b^2+c^2+d^2 = \frac{1}{2} \quad (\text{equ. 32})$$

Take two consecutive H,G pairs:

$$H\left(\frac{x}{2}\right) = aD(x-1)+bD(x)+cD(x+1)-dD(x+2) \quad (\text{equ. 33})$$

$$G\left(\frac{x}{2}\right) = dD(x-1)+cD(x)-bD(x+1)+aD(x+2) \quad (\text{equ. 34})$$

$$H\left(\frac{x}{2}+1\right) = aD(x+1)+bD(x+2)+cD(x+3)-dD(x+4) \quad (\text{equ. 35})$$

$$25 \quad G\left(\frac{x}{2}+1\right) = dD(x+1)+cD(x+2)-bD(x+3)+aD(x+4) \quad (\text{equ. 36})$$

Multiplying Equations 33 to 36 using the inverse transform digital filters gives:

- 43 -

$$cH\left(\frac{x}{2}\right) = acD(x-1) + bcD(x) + c^2D(x+1) - cdD(x+2) \quad (\text{equ. 37})$$

$$-bG\left(\frac{x}{2}\right) = -bdD(x-1) - bcD(x) + b^2D(x+1) - abD(x+2) \quad (\text{equ. 38})$$

$$aH\left(\frac{x}{2}+1\right) = a^2D(x+1) + abD(x+2) + acD(x+3) - adD(x+4) \quad (\text{equ. 39})$$

$$dG\left(\frac{x}{2}+1\right) = d^2D(x+1) + cdD(x+2) - bdD(x+3) + adD(x+4) \quad (\text{equ. 40})$$

$$5 \quad -dH\left(\frac{x}{2}\right) = -adD(x-1) - bdD(x) - cdD(x+1) + d^2D(x+2) \quad (\text{equ. 41})$$

$$aG\left(\frac{x}{2}\right) = adD(x-1) + acD(x) - abD(x+1) + a^2D(x+2) \quad (\text{equ. 42})$$

$$bH\left(\frac{x}{2}+1\right) = abD(x+1) + b^2D(x+2) + bcD(x+3) - bdD(x+4) \quad (\text{equ. 43})$$

$$cG\left(\frac{x}{2}+1\right) = cdD(x+1) + c^2D(x+2) - bcD(x+3) + acD(x+4) \quad (\text{equ. 44})$$

Summing equations 37-40 and 41-44 yields:

$$10 \quad cH\left(\frac{x}{2}\right) - bG\left(\frac{x}{2}\right) + aH\left(\frac{x}{2}+1\right) + dG\left(\frac{x}{2}+1\right) = \\ (ac-bd)D(x-1) + (a^2+b^2+c^2+d^2)D(x+1) + (ac-bd)D(x+3) = D(x+1)/2 \quad (\text{equ. 45})$$

$$-dH\left(\frac{x}{2}\right) + aG\left(\frac{x}{2}\right) + bH\left(\frac{x}{2}+1\right) + cG\left(\frac{x}{2}+1\right) = \\ (ac-bd)D(x) + (a^2+b^2+c^2+d^2)D(x+2) + (ac-bd)D(x+4) = D(x+2)/2 \quad (\text{equ. 46})$$

Using the coefficients of the four coefficient true Daubechies filter, the relationships of equations 31 and 32 hold. Equations 45 and 46 therefore show that with a one bit shift at the output, the original sequence of data values is reconstructed.

Similarly, that the even start reconstruction filter of equation 29 and the odd end reconstruction filter of equation 30 correctly reconstruct the original image data adjacent the boundaries is shown as follows.

For the even start filter, with the choice of  $K1 = aD_0$  and  $K2 = dD_0$  in equations 29 and 30, we have:

- 44 -

$$H_0 = (a+b)D_0 + cD_1 - dD_2 \quad (\text{equ. 47})$$

$$G_0 = (c+d)D_0 - bD_1 + aD_2 \quad (\text{equ. 48})$$

so

$$bH_0 = b(a+b)D_0 + cbD_1 - dbD_2 \quad (\text{equ. 49})$$

$$5 \quad cG_0 = c(c+d)D_0 - cbD_1 + acD_2 \quad (\text{equ. 50})$$

$$aH_0 = a(a+b)D_0 + acD_1 - adD_2 \quad (\text{equ. 51})$$

$$dG_0 = d(c+d)D_0 - dbD_1 + adD_2 \quad (\text{equ. 51'})$$

and hence: from equation 29:

$$bH_0 + cG_0 - aH_0 - dG_0 = (b^2 - a^2 + c^2 - d^2)D_0 = \frac{D_0}{4} \quad (\text{equ. 52})$$

10 For the odd end filter, with the choice of  $K_3 = dD_B$   
and  $K_4 = aD_B$ , we have:

$$H_5 = aD_9 + bD_A + (c-d)D_B \quad (\text{equ. 53})$$

$$G_5 = dD_9 + cD_A + (a-b)D_B \quad (\text{equ. 54})$$

$$cH_5 = acD_9 + bcD_A + c(c-d)D_B \quad (\text{equ. 55})$$

$$15 \quad -bG_5 = -bdD_9 - bcD_A - b(a-b)D_B \quad (\text{equ. 56})$$

$$dH_5 = daD_9 + bdD_A + d(c-d)D_B \quad (\text{equ. 57})$$

$$-aG_5 = -adD_9 - caD_A - a(a-b)D_B \quad (\text{equ. 58})$$

and hence from equation 30:

$$(c+d)H_5 - (a+b)G_5 = (c^2 - d^2 + b^2 - a^2)D_B = \frac{D_B}{4} \quad (\text{equ. 59})$$

- 45 -

This reveals that the start and end boundary inverse transform digital filters can reconstruct the boundary data values of the original image when low pass and high pass start and end digital filters are used in the forward  
5 transform.

#### TREE ENCODING AND DECODING

As described above, performing the forward quasi-perfect inverse transform does not reduce the number of data values carrying the image information. Accordingly,  
10 the decomposed data values are encoded such that not all of the data values need be stored or transmitted. The present invention takes advantage of characteristics of the Human Visual System to encode more visually important information with a relatively larger number of bits while  
15 encoding less visually important information with a relatively smaller number of bits.

By applying the forward quasi-perfect inverse transform to a two-dimensional array of image data values, a number of sub-band images of varying dimensions and  
20 spectral contents is obtained. If traditional sub-band coding were used, then the sub-band images would be encoded separately without reference to each other except perhaps for a weighting factor for each band. This traditional sub-band encoding method is the most readily-  
25 recognized encoding method because only the spectral response is accurately localized in each band.

In accordance with the present invention, however, a finite support wavelet is used in the analysis of an image, so that the sub-bands of the decomposition include  
30 spatially local information which indicate the spatial locations in which the frequency band occurs. Whereas most sub-band encoding methods use long filters in order to achieve superior frequency separation and maximal stop band rejection, the filter used in the present invention  
35 has compromised frequency characteristics in order to maintain good spatial locality.

- 46 -

Images can be thought of as comprising three components: background intensities, edges and textures. The forward quasi-perfect inverse transform separates the background intensities (the low pass luminance and chrominance bands) from the edge and texture information contained in the high frequency bands. Ideally, enough bandwidth would be available to encode both the edges and the textures so that the image would reconstruct perfectly. The compression due to the encoding would then be entirely due to removal of redundancy within the picture. If, however, the compressed data is to be transmitted and/or stored at low data transmission rates, some visual information of complex images must be lost. Because edges are a visually important image feature, the encoding method of the present invention locates and encodes information about edges or edge-like features for transmission or storage and places less importance on encoding textural information.

There are no exact definitions of what constitutes an edge and what constitutes texture. The present invention uses a definition of an edge that includes many types of textures. An edge or an edge-like feature is defined as a spatially local phenomenon giving rise to a sharp discontinuity in intensity, the edge or edge-like feature having non-zero spectral components over a range of frequencies. Accordingly, the present invention uses a frequency decomposition which incorporates spatial locality and which is invertible. The wavelet transform realized with quasi-perfect inverse transform digital filters meets these requirements.

Because an edge has non-zero components over a range of frequencies of the decomposition in the same locality, an edge can be located by searching through the wavelet decomposition for non-zero data values that represent edges. The method begins searching for edges by examining the low frequency sub-bands of the decomposition. These bands have only a small number of data values because of

the subsampling used in the wavelet transform and because the spatial support of each low frequency data value is large. After a quick search of the lowest frequency sub-bands, the positions of potential edges are determined.

5 Once the locations of the edges are determined in the lowest frequency sub-bands, these locations can be examined at a higher frequency resolutions to confirm that the edges exist and to more accurately determine their spatial locations.

10 Figure 23 illustrates an example of a one-dimensional binary search. There are three binary trees arranged from left to right in the decomposition of Figure 23. There are three octaves, octaves 0, 1 and 2, of decomposed data values in Figure 23. The low pass component is not  
15 considered to be an octave of the decomposition because most of the edge information has been filtered out. Figures 24A-24D illustrate the forward transformation of a one-dimensional sequence of data values D into a sequence of transformed data values such as the tree structure of  
20 Figure 23. The data values of the sequence of Figure 24A are filtered into low and high frequency components H and G of Figure 24B. The low frequency component of Figure 24B is then filtered into low and high frequency components HH and HG of Figure 24C. The low frequency  
25 component HH of Figure 24C is then filtered into low and high frequency components HHH and HHG. The transformed data values of HHH block 240 of Figure 24D correspond with the low frequency component data values A, G and M of Figure 23. The transformed data values of HHG block 241  
30 of Figure 24D correspond with the octave 2 data values B, H and N of Figure 23. The transformed data values of HG block 242 of Figure 24D correspond with the octave 1 data values of Figure 23. Similarly, the transformed data values of G block 243 correspond with the octave 0 data  
35 values of Figure 23. Although only three trees are shown in Figure 23, the number of HHH data values in block 240 can be large and the size of the tree structure of Figure

- 48 -

23 can extend in the horizontal dimension in a corresponding manner.

The encoding of a one dimensional wavelet decomposition such as the decomposition of Figure 23 is performed in similar fashion to a binary tree search. The spatial support of a given data value in a given frequency band is the same as two data values in the octave above it in frequency. Thus the wavelet decomposition is visualized as an array of binary trees such as is illustrated in Figure 23, each tree representing a spatial locality. The greater the number of transform octaves, the higher the trees extend upward and the fewer their number.

As illustrated in Figure 23, each of the data values of the decomposition represents a feature which is either "interesting" to the human visual system, or it represents a feature that is "non-interesting" to the human visual system. A data value representing an edge of an object in an image or an edge-like feature is an example of an "interesting" data value. The encoding method is a depth first search, which starts at the trunk of a tree, ascends up the branches of the tree that are interesting, and terminates at the non-interesting branches. After all the branches of a tree have been ascended until a non-interesting data value is encountered or until the top of the branch is reached, the encoding of another tree is begun. Accordingly, as the encoding method follows the interesting data values of Figure 23 from octave 2 to octave 1 to octave 0, the edge is followed from low to high frequency resolution and an increasingly better approximation to the spatial position and shape of the edge is made. Conversely, if at any stage, a non-interesting data value is found, the search is terminated for data values above that non-interesting data value. The higher frequency data values of the tree above a non-interesting data value are assumed to be non-interesting because the corresponding low frequency data



- 49 -

values did not indicate the presence of an edge at this location. Any interesting data values that do exist in the higher frequency bands above a non-interesting data value in a low frequency band are rejected as noise.

5       The one-dimensional tree structure of Figure 23 is encoded as follows. The low frequency components carry visually important information and are therefore always considered to be "interesting". The method of encoding therefore starts with low frequency component A. This  
10 data value is encoded. Next, the octave 2 data value B is tested to determine if it represents an edge or an edge-like feature which is "interesting" to the human visual system. Because data value B is interesting, a token is generated representing that the bits to follow will  
15 represent an encoded data value. Interesting data value B is then encoded. Because this tree has not yet terminated, the method continues upward in frequency. Data value C of octave 1 is then tested. For purpose of this example, data value C is considered to be interesting  
20 as are data values A, B, C, D, G, H, J, L and M as illustrated in Figure 23. A token is therefore generated indicating an encoded data value will follow. After the token is sent, data value C is encoded. Because this branch has still not terminated in a non-interesting data  
25 value, the method continues upward in frequency. Data value D is tested to determine whether or not it is interesting. Because data value D is interesting, a token is generated and data value D is encoded. Because octave 0 is the highest octave in the decomposition, the encoding  
30 method tests the other branch originating from previous interesting data value C. Data value E however tests to be non-interesting. A non-interesting token is therefore generated. Data value E is not encoded and does not appear in the compressed data. With both branches  
35 originating at data value C terminated, the method proceeds down in frequency to test the remaining branches originating from the previous interesting data value B.

- 50 -

Data value F is, however, determined to be non-interesting. A non-interesting token is therefore generated and data value F is not encoded and does not appear in the encoded data. Because this branch has  
5 terminated, all data values higher in frequency above data value F are considered to be non-interesting. A decoding device receiving the sequence of encoded data values and tokens can determine from the non-interesting token that all corresponding higher frequency data values were  
10 considered to be non-interesting by the encoding device. The decoding device can therefore write the appropriate data values as non-interesting and write zeroes to these locations obviating the need for the encoding device to transmit each non-interesting data value above F. With  
15 the first tree encoded, the method proceeds to the next low frequency component, data value G. This is a low frequency component and therefore is always considered to be interesting. Data value G is therefore encoded. The method then proceeds to the next tree through blocks H, I,  
20 J, K and L in that order generating interesting and non-interesting tokens and encoding interesting data values. Similarly, after the second tree is terminated, low frequency component data value M is encoded. Data value N is determined to be non-interesting so a non-interesting  
25 token is sent and the encoding of the third tree is terminated.

In accordance with another embodiment of the present invention, a two-dimensional extension of the one-dimensional case is used. Rather than using binary trees,  
30 four branch trees are used. However, to create a practical image encoding method there are also real world factors to take into account. Using a single data value to predict whether the remainder of the tree is zero, is unreliable when dealing with noisy image data. A small  
35 two-by-two block of data values is therefore used as the node element in the tree structure of the two-dimensional embodiment. A decision as to whether or not an edge is

- 51 -

present is based on four data values which is more reliable than a decision based on single data value.

Figure 25 illustrates a tree structure representing a portion of the decomposition of Figure 18. The decomposition of Figure 18 may extend farther to the right and farther in a downward direction for larger two-dimensional arrays of image data values. Similarly, the tree structure of Figure 25 may extend farther to the right for larger arrays of data values. Figure 25 represents a decomposition only having octave 0 and 1 high frequency components. In the event that the decomposition had additional octaves of high frequency components, the tree structure would extend further upward. In contrast to the binary tree structure of Figure 23, the tree structure of Figure 25 is a four branch tree. The two-by-two block of four octave 1 data values HHHG is the root of a tree which extends upward in frequency to four HG two-by-two blocks. If another octave of decomposition were performed, another level of octave 2 high frequency two-by-two blocks would be inserted into the tree structure. Four HHHG octave 1 two-by-two blocks would, for example, have a single octave 2 HHHHHG block beneath them. The low frequency component would be denoted HHHHHH.

Figure 26 is a pictorial representation of the decomposition of the tree structure of Figure 25. As explained above with respect to Figure 15, the actual data values of the various denoted blocks are distributed throughout the two-dimensional array of data values. The two numbers separated by a comma in each of the boxes of Figure 25 denote the row and column of a data value of the two-dimensional array of Figure 18, respectively. Using this tree structure, it is possible to search through the transformed data values of Figure 18 encoding interesting two-by-two blocks of data values and ignoring non-interesting two-by-two blocks.

To describe how the two dimensional encoding method uses the tree structure to search through a decomposition,

- 52 -

some useful definitions are introduced. First an image *decomp* is defined with dimensions *WIDTH* by *HEIGHT* decomposed to number *OCTS* of octaves. A function *Access* is defined such that given some arguments, the function  
 5 *Access* outputs the memory address of the specified data value in the wavelet decomposition *decomp*:

```
address = Access (oct, sub, x, y);
```

*oct* is the octave of the data value sought and is an integer value between 0 (the highest octave) and *OCTS-1*  
 10 (the number of octaves of transformation *OCTS* minus one). *sub* indicates which of the *HH*, *HG*, *GH* or *GG* bands of the decomposition it is that the data value sought is found. The use of *sub* = *HH* to access the low pass data values is only valid when the value of *oct* is set to that of the  
 15 lowest octave. The co-ordinates *x* and *y* indicate the spatial location from the top left hand corner of the sub-band specified by *oct* and *sub*. The range of valid values of *x* and *y* are dependent on the octave being accessed. *x* has a range of {0 . . .  $WIDTH/2^{oct+1}$ }. *y* has a range of {0 .  
 20 . . .  $HEIGHT/2^{oct+1}$ }.

Given the function *Access* and a wavelet decomposition, a two-by-two block of data values can be read by the function *ReadBlock*.

```
block = ReadBlock (decomp, oct, sub, x, y) {  

  25   block[0][0] = decomp[Access(oct, sub, x, y)];  

      block[0][1] = decomp[Access(oct, sub, x+1, y)];  

      block[1][0] = decomp[Access(oct, sub, x, y+1)];  

      block[1][1] = decomp[Access(oct, sub, x+1, y+1)];  

  }
```

30 The wavelet decomposition is passed to the function *ReadBlock* via the variable *decomp*. The two-by-two block of data values is returned through the variable *block*.

Once a two-by-two block of data values is read, a

- 53 -

decision is made as to whether the two-by-two block is visually "interesting" and should therefore be encoded or whether it is not and hence should be discarded. The decision is made by a function called *Threshold*. The arguments of the function *Threshold* are *block*, *oct* and *sub*. *Threshold* returns a boolean value *True* if the block is "interesting" and *False* if the block is "non-interesting".

If the block is determined to be interesting by the function *threshold*, it is encoded using a function called *EncodeBlock*. A function *SendToken* inserts a token before the encoded block to inform a decoding device which will later decode the compressed data whether the block to follow the token has been encoded (i.e. *BlockNotEmpty*) or has not been encoded (i.e. *BlockEmpty*). If a block is determined to be interesting, then a *BlockNotEmpty* token is sent, and the block is encoded; next the tree structure above the encoded block is ascended to better determine the location of the edge. The tree encoding procedure *SendTree* is therefore defined recursively as follows:

```

SendTree (decomp, oct, sub, x, y, Q) {
    block = ReadBlock (decomp, oct, sub, x, y);
    If Threshold (block, oct, sub, Q) {
        SendToken (BlockNotEmpty);
25    EncodeBlock (block, oct, sub, Q);
        If (oct > 0) {
            SendTree (decomp, oct-1, sub, 2*x, 2*y, Q);
            SendTree (decomp, oct-1, sub, 2*(x+1), 2*y, Q);
            SendTree (decomp, oct-1, sub, 2*x, 2*(y+1), Q);
30            SendTree (decomp, oct-1, sub, 2*(x+1), 2*(y+1), Q);
        }
    } else SendToken (BlockEmpty);
}

```

The procedure *SendTree* is only used to encode high-pass component data values. In procedure *SendTree*

- 54 -

(*decomp*, *oct*, *sub*, *x*, *y*, *Q*), if the two-by-two block accessed by *ReadBlock* is determined to pass the threshold test, then *SendTree* (*decomp*, *oct*-1, *sub* 2\*X, 2\*y, *Q*) is used to test one of the next higher two-by-two blocks in 5 the decomposition tree.

The low-pass data values are not considered to form part of the tree structure. The low-pass data values are encoded using another procedure *SendLPF*. In addition, the low-pass values are encoded using a different technique 10 than that used in *EncodeBlock*, so a new procedure *EncodeBlockLPF* is required.

```

SendLPF (decomp, x, y, Q) {
    block = Readblock (decomp, OCTS-1, HH, x, y);
    EncodeBlockLPF (block, OCTS-1, Q);
15 }
```

Accordingly, to encode the entire image, *SendLPF* is applied to all the block locations within the low pass band and *SendTree* is applied to the all the block locations in the HG, GH and GG bands, within the lowest 20 octave. A procedure *SendDecomp* is therefore defined that encodes the entire image decomposition:

```

SendDecomp (decomp, Q) {
    For (y=0; y<HEIGHT/2OCTS; y=y+2)
    For (x=0; x<WIDTH/2OCTS; x=x+2) {
25      SendLPF (decomp, x, y, Q);
      SendTree (decomp, OCTS-1, HG, x, y, Q);
      SendTree (decomp, OCTS-1, GH, x, y, Q);
      SendTree (decomp, OCTS-1, GG, x, y, Q);
    }
30 }
```

Accordingly, the above functions define a method for encoding wavelet decomposed images. In terms of speed of encoding for real-world images, many of the trees are

- 55 -

terminated within the initial octaves so much of the decomposition is not examined. Due to this termination of many trees in the initial octaves, many data values need not be encoded which results in reducing the memory bandwidth and block processing required to implement the compression/decompression method. Provided the functions *Threshold*, *EncodeBlockLPF* and *Access* require only simple calculations, the decomposed data values are rapidly encoded.

10 To implement the function *Access*, a table containing all the addresses of the data values of the two-dimensional tree decomposition may be accessed using the variables *x*, *y*, *sub* and *oct*. For a small image having a small number of data values, this table lookup approach is

15 reasonable. For images having, for example, approximately 80 different values of *x*, 60 different values of *y*, four different values of *sub*, and 3 or 4 values for *oct*, this table would contain approximately 150,000 10-bit locations. A less memory intensive way of determining the

20 same *X* and *Y* addresses from the same variables is desirable.

In accordance with one embodiment of the present invention, a function is used to determine the *X* and *Y* addresses from the variables *x*, *y*, *sub* and *oct*. Address

25 *X*, for example, may be determined as follows:

$$X = ((x \ll 1) + (sub \gg 1)) \ll oct$$

where  $\ll$  denotes one shift to the right of value *x* and where  $\gg$  denotes one shift to the left.

Address *Y*, for example, may be determined as follows:

30 
$$Y = ((y \ll 1) + (1 \& sub)) \ll oct$$

where  $\&$  denotes a bit-wise AND function.

In a high performance system, the function *Access* may be implemented according to the following method. The

- 56 -

recursive function call and the table lookup methods described above are often too slow to implement in real time software or in hardware. Figures 27 and 28 illustrate how the tree decomposition of Figure 25 is traversed in order to generate tokens and encode two-by-two blocks of data values. The X and the Y in Figures 27 and 28 denote coordinate addresses in the two-dimensional matrix of Figure 18. In order to traverse the tree of the decomposition of Figure 25, it is necessary to be able to determine the X and Y addresses of the data values represented in Figure 25. Figure 27 illustrates how the X and Y address of a two-by-two block of data values are determined for those two-by-two blocks of data values located in octave 0 of the decomposition of Figure 25. Similarly, Figure 28 illustrates how the X and Y addresses of the three two-by-two blocks of data values in octave 1 of the decomposition as well as the one two-by-two block of data values of the low pass component of the decomposition of Figure 25 are determined. X as well as Y are each functions of *oct*, *TreeRoot*, and *sub*. The values of *sub<sub>x</sub>* and *sub<sub>y</sub>* are determined by the sub-band of the two-by-two block of data values sought.

Figure 29 is a chart illustrating the values of *sub<sub>x</sub>* and *sub<sub>y</sub>* for each sub-band of the decomposition. If, for example, a two-by-two block of data values is sought in the HH band, then the values of *sub<sub>x</sub>* and *sub<sub>y</sub>* are 0 and 0, respectively. The values *TreeRoot<sub>x</sub>* and *TreeRoot<sub>y</sub>*, together denote the particular tree of a decomposition containing the particular two-by-two block of the data values sought.

In Figures 27 and 28, the rectangles represent digital counters. The arrows interconnecting the rectangles indicate a sequence of incrementing the counters. For example, the right most rectangle in Figure 27, which is called counter C1, has a least significant bit represented in Figure 27 as bit C1<sub>1</sub> and a most significant bit represented as bit C1<sub>7</sub>. Similarly, the next rectangle to the left in Figure 27 represents a



- 57 -

digital counter C2 having two bits, a least significant bit  $C2_x$  and a most significant bit  $C2_y$ . The structure of the X, Y address depends on the octave in which the two-by-two block of data values being sought resides. To  
5 generate the X, Y address in octave  $oct = 1$ , the counter C1 is not included, the  $sub_x$  and  $sub_y$  bits indicating the sub-band bits are shifted one place to the left, and the least significant bits are filled with zeros. The incrementing of the counters in Figure 28 proceeds as  
10 illustrated by the arrows.

To determine the X and Y addresses of the four data values of the low pass component HHHH of Figure 25, Figure 28 is used. Because the two-by-two block of data values being sought is a two-by-two block of the low pass  
15 component, the values of  $sub_x$  and  $sub_y$  are 0, 0 as required by the table of Figure 29. The C2 counter of Figure 28 increments through the four possible values of  $C2_x$  and  $C2_y$  to generate the four addresses in the two-by-two block of data values of the HHHH in the low pass component of  
20 Figure 25. The value of  $TreeRoot_x$  and  $TreeRoot_y$  are zeroes because this is the first tree of the decomposition. For subsequent trees of the decomposition,  $TreeRoot_x$  and  $TreeRoot_y$  are incremented as illustrated by the arrows in Figure 28 so that the X and Y addresses of the other two-  
25 by-two blocks of data values in the low pass component of the tree decomposition can be determined. After this HHHH two-by-two block of data values is located, the four data values are encoded and the search through the tree structure proceeds to the two-by-two block of data values  
30 in octave 1 denoted HHHG in Figure 25. To determine the X and Y addresses of the four data values of this two-by-two block, the value of bits  $sub_x$  and  $sub_y$  are changed in accordance with Figure 29. Because this two-by-two block is in the HG sub-band, the values of  $sub_x$  and  $sub_y$  are 0  
35 and 1, respectively. The C2 counter is then incremented through its four values to generate the four addresses of the four data values in that block. Supposing, that this

- 58 -

two-by-two block is determined to be "interesting" then an interesting token is sent, each of the four data values of the block are encoded, and the tree is then ascended to the two-by-two block of data values in octave 0 denoted

5 HG#1. These four addresses are determined in accordance with Figure 27. Because the sub-band is sub-band HG, the values of the bits  $sub_x$  and  $sub_y$  are 0 and 1, respectively. Counter C1 is then incremented so that the four addresses illustrated in the two-by-two block octave 0 HG#1 of

10 Figure 25 are generated. If the two-by-two block is interesting, then the interesting token is sent and the four data values are encoded. If the two-by-two block is determined not to be interesting, then a non-interesting token is sent and the four data values are not encoded.

15 The search through the tree structure of the decomposition then proceeds to octave 0 block HG#2. After the four addresses of the octave 0 block HG#1 are generated, the C2<sub>x</sub> bit of the C2 counter is incremented in accordance with the arrows shown in Figure 27. Accordingly, the octave 0

20 block HG#2 is addressed when once again the C1 counter increments through its four states. If the data values of this two-by-two block are determined to be "interesting", an interesting token is sent followed by the encoded data values. If the data values of the two-by-two block are

25 determined to be non-interesting, then a non-interesting token is sent. After all the search of the four two-by-two blocks of the octave 0 HG sub-band are searched, then that HG tree is terminated and the search proceeds to determine the four addresses of the four data values of

30 the octave 1 HHGH two-by-two block. In accordance with this technique, it is possible to traverse the structure of the decomposition and determine the addresses of any two-by-two block in any octave or any sub-band with minimum overhead. Moving between consecutive addresses or

35 descending trees is a simple operation when compared to the snaking address path used by other compression methods such as JPEG.

- 59 -

When implemented in software, this technique enables real time compression and decompression whereas other techniques may be too slow. If implemented in hardware, this technique provides for a reduced gate count and an efficient implementation. Although this example shows one way of traversing the tree structure of wavelet transform decomposition, it is possible to traverse the tree structure in other ways simply by changing the control structure represented in Figures 27 and 28 to allow for a different traversal of the tree structure. For example, all of the low pass HHHH blocks can be located and encoded first followed by all of the HHHG tree of the decomposition, and then all of the HHGH trees, and then all of the HHGG trees.

15

## QUANTIZATION

Each data value of each two-by-two block of the tree decomposition which is determined to be "interesting" is quantized and then Huffman encoded. A linear mid-step quantizer with double-width-0 step is used to quantize each of the data values. Figure 30 is an illustration of the quantization of a 10-bit twos complement data value. The range of the 10-bit data value to be quantized ranges from -512 to 511 as illustrated by the numbers above the horizontal line in Figure 30. This range is broken up into a plurality of steps. Figure 31 represents one such step of data values which extends from 128 to 256 in Figure 30. All incoming data values having values between 128 and 255 inclusive are quantized by dividing the data value by the value  $qstep$ . Accordingly, the data value A having a value of 150 as illustrated in Figure 31 is divided by the  $qstep$  value 128 and results in a  $qindex$  number of 1. Integer division is used to generate  $qindex$  and the fractional part of the remainder is discarded. Once the  $qindex$  number is determined, the  $qindex$  number is Huffman encoded. An overall  $Q$  value is sent once per frame of compressed data values. The value  $qstep$  is

- 60 -

determined from the overall  $Q$  value as described below.

To inverse quantize the  $qindex$  number and the  $qstep$  value to determine the value of the transformed data values before inverse transformation, the device decoding  
 5 the incoming quantized values calculates the value of  $qstep$  using the value of  $Q$  according to a method described below. Once the value of  $qstep$  is determined,  $qindex$  for a given data value is multiplied by  $qstep$ .

In the example of Figure 31,  $qindex$  value 1 times  
 10  $qstep$  128 results in an inverse quantized value of 128. If this inverse quantized value of 128 were used, however, all the data values in the step 128 through 255 would be inverse quantized to the value of 128 at the left end of the step. This would result in unacceptably large errors.  
 15 On the other hand, if all the data values in the range of Figure 31 were inverse quantized to the mid-step value 191, then less error would result. Accordingly, an inverse quantized value  $qvalue$  can be calculated from  $qindex$  and  $qstep$  as follows:

$$20 \quad qvalue(qindex, qstep) = \begin{cases} qindex * qstep - \left( \frac{qstep}{2} - 1 \right) & \text{if } qindex < 0 \\ 0 & \text{if } qindex = 0 \\ qindex * qstep + \left( \frac{qstep}{2} - 1 \right) & \text{if } qindex > 0 \end{cases}$$

The human visual system, however, has different sensitivities to quantization errors depending upon the particular sub-band containing the quantized data values. The human visual system performs complex non-linear  
 25 processing. Although the way the human visual system relates image intensities to recognizable structures is not well understood, it is nevertheless important to take advantage of as much information about the human visual system as possible in order to maximize compression ratio  
 30 versus picture quality. The wavelet transform approximates the initial image processing performed by the human brain. Factors such as spatial frequency response and Weber's Law can therefore be applied directly to the

- 61 -

wavelet transformed data values because the transformed data values are in a convenient representation.

Figure 32 shows the sensitivity of the human eye to spatial frequency. Spatial frequency is measured in 5 cycles  $c$  per visual angle  $\theta$ . A screen is positioned at a distance  $d$  from an observer as illustrated in Figure 33. A light of sinusoidally varying luminance is projected onto the screen. The spatial frequency is the number of luminance cycles  $c$  per visual degree  $\theta$  at distance  $d$ .

10 Note from Figure 32 that the sensitivity of the human eye varies with spatial frequency. Accordingly, the value of  $qstep$  is varied depending on the octave and sub-band of the data valve being quantized. The  $qstep$  at which a data valve is quantized is determined from the variables 15  $oct$ ,  $sub$  and  $Q$  for that data valve as follows:

$$qstep(oct, sub, Q) = Q * hvs\_factor(oct, sub)$$

$$hvs\_factor(oct, sub) = \begin{cases} \sqrt{2} & \text{if } sub=GG \\ 1 & \text{otherwise} \end{cases} * \begin{cases} 1.00 & \text{if } oct=0 \\ 0.32 & \text{if } oct=1 \\ 0.16 & \text{if } oct=2 \\ 0.10 & \text{if } oct=3 \end{cases}$$

The scaling factors 1.00, 0.32, 0.16 and 0.10 relate to the spatial frequency scale of Figure 32 to take into 20 account the frequency dependent sensitivity of the human eye.

It is to be understood that scaling factors other than 1.00, 0.32, 0.16 and 0.10 could be used. For example, other scaling factors can be used where the 25 quantizer is used to compress audio data which is received by the human ear rather than by the human eye. Moreover, note that the sub-band GG is quantized more heavily than the other sub-bands because the sub-band GG contains diagonal information which is less important to the human 30 eye than horizontal and vertical information. This method can also be extended down to the level of two-by-two blocks of data values to further tailor the degree of quantization to the human visual system. The function

- 62 -

*hvs\_factor* which has only two parameters in the presently described embodiment is only one embodiment of the present invention. The function *hvs\_factor*, for example, can take into account other characteristics of the human visual system other than oct and sub, such as the luminance of the background and texture masking.

#### THRESHOLDING

For each new two-by-two block of data values in the tree decomposition, a decision must be made as to whether the block is "interesting" or "non-interesting". This can be done by the function *threshold*:

$$\text{threshold}(\text{block}, \text{limit}) = \text{limit} > \sum_{y=0}^1 \sum_{x=0}^1 |\text{block}[y][x]| \quad (\text{equ. 60})$$

The sum of the absolute values of the data values of the block *block* is determined as is represented by the double summation to the right of the less than sign and this value is compared to a threshold value *limit*.

"Interesting" blocks are those blocks, for which the sum of the absolute values of the four data values exceeds the value *limit*, whereas "non-interesting" blocks are those blocks for which the sum is less than or equal to the value *limit*.

The value *limit* takes into account the variable quantizer step size *qstep* which varies with octave. For example, a two-by-two block of data values could be determined to pass the test *threshold*, but after quantizing by *qstep* could result in four zero quantized values. For example, all data values between -128 and 127 are quantized to have a quantized *qindex* of zero as is shown in Figure 30 even if some of those data values are determined to correspond with an "interesting" two-by-two block. For this reason, the value *limit* is calculated according to the equation:

- 63 -

$$\text{limit} = 4 * \text{Bthreshold} * \text{qstep} \quad (\text{equ. 61})$$

In this equation "Bthreshold" is base threshold image factor. In the presently described example, this base threshold is equal to 1.0. The value of 1.0 for the base threshold *Bthreshold* was determined through extensive experimentation on test images. The factor 4 in equation 61 is included to account for the fact that there are four data values in the block under consideration. In this way blocks are not determined to be interesting, the data values for which the quantizer will later reduce to zeros. This weighted threshold factor *limit* also reduces the number of operations performed in the quantizer because a fewer number of data values are quantized.

#### HUFFMAN CODING

The wavelet transform produces transformed data values whose statistics are vastly different from the data values of the original image. The transformed data values of the high-pass sub-bands have a probability distribution that is similar to an exponential or Laplacian characteristic with mean zero.

Figure 34 shows the distribution of high pass data values in a four octave wavelet decomposition of the test image Lenna. Figure 35 shows the distribution of the data values of the test image Lenna before wavelet transformation. The low-pass component data values have a flat distribution that approximates the distribution of luminance and chrominance values in the original image. The high and low pass data values are encoded differently for this reason.

The low pass component data values are encoded by the function *EncodeBlockLPF* as follows:

```

EncodeBlockLPF ( block, OCT-1, Q) {
    Output ( block[0][0]/qstep( OCT-1, HH, Q));
    Output ( block[0][1]/qstep( OCT-1, HH, Q));
    Output ( block[1][0]/qstep( OCT-1, HH, Q));

```

- 64 -

```
Output ( block[1][1]/qstep( OCT-1, HH, Q));}
```

After encoding, the low-pass data values are quantized and output into the compressed data stream. The low pass data values are not Huffman encoded.

- 5       The high frequency component data values which pass the threshold test are quantized and Huffman encoded to take advantage of their Laplacian distribution. Function *EncodeBlock* performs the quantization and the Huffman encoding for each of the four data values of an
- 10 interesting high frequency component block *block*. In the function *EncodeBlock*, the variable *sub* is provided so that when function *qstep* is called, different quantization *qstep* values can be used for different high frequency component sub-bands. The function *huffman* performs a
- 15 table lookup to a fixed Huffman code table such as the table of Table 3. The function *EncodeBlock* is defined as follows:

```
EncodeBlock (block, oct, sub, Q) {
    Output(huffman(block[0][0]/qstep(oct, sub, Q)));
20   Output(huffman(block[0][1]/qstep(oct, sub, Q)));
    Output(huffman(block[1][0]/qstep(oct, sub, Q)));
    Output(huffman(block[1][1]/qstep(oct, sub, Q)));
}
```



- 65 -

	<i>qindex</i>	Huffman code
	-38 . . . -512	1 1 0 0 0 0 0 0 1 1 1 1 1 1 1 1
	-22 . . -37	1 1 0 0 0 0 0 0 1 1 1 1 ( <i> qindex </i> -22)
	-7 . . -21	1 1 0 0 0 0 0 0 ( <i> qindex </i> -7)
5	-6	1 1 0 0 0 0 0 1
	.	.
	.	.
	.	.
	-2	1 1 0 1
10	-1	1 1 1
	0	0
	1	1 0 1
	2	1 0 0 1
	.	.
15	.	.
	.	.
	6	1 0 0 0 0 0 0 1
	7 . . 21	1 0 0 0 0 0 0 0 ( <i> qindex </i> -7)
	22 . . 37	1 0 0 0 0 0 0 0 1 1 1 1 ( <i> qindex </i> -22)
20	38 . . 511	1 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1

Table 3

The second bit from the left in the Huffman code of Table 3 is a sign bit. The value  $|qindex|-7$  is represented with 4 bits in the case  $7 \leq |qindex| \leq 21$ . The value  $|qindex|-22$  is represented with 4 bits in the case  $22 \leq |qindex| \leq 37$ .

## ENCODING OF TOKENS

At high compression ratios the number of bits in the compressed data stream used by tokens may be reduced by amalgamating groups of "non-interesting" tokens. This can be achieved by introducing new tokens. In accordance with one embodiment of the present invention, two new tokens, *OctEmpty* and *OctNotEmpty* are used. For a high pass component block in a tree above octave zero, there are four branches. The additional pair of tokens indicate

- 66 -

whether all four are non-interesting. If all four are non-interesting, only a single *OctEmpty* token need be sent. Otherwise, an *OctNotEmpty* token is generated before the four branches are encoded. The particular token

5 scheme described above was selected more to simplify the hardware and software implementations than it was to achieve in the best compression ratio possible. Other methods of representing relatively long sequences of token bits in the compressed data stream using other tokens

10 having a relatively fewer number of bits may be used in place of the tokens *OctEmpty* and *OctNotEmpty* to achieve higher compression ratios.

#### VIDEO ENCODING AND DECODING

In comparison with the coding of a still image, the

15 successive images of a video sequence typically contain much redundant information. The redundancy of this information is used to reduce the bit rate. If a location in a new frame of the video contains the same or substantially the same information as a corresponding

20 location in the previous old frame of video, that portion of the new frame need not be encoded and introduced into the compressed data. This results in a reduction in the total number of bits in the encoded bit stream.

Figure 36 illustrates a video encoder 31 and a video

25 decoder 32. A video input signal is transformed by a forward wavelet transform block 33, the output of which is written to a new frame store 34. The first frame of video information in the new frame store 34 is referred to as the new frame because no previous frame exists in the old

30 frame store 35 for containing an old frame. A comparison tree encoder 36 therefore generates tokens and transformed data values as described above from the data values output from new frame store 34. The transformed data values are quantized by quantizer 37 into *qindex* levels. These

35 *qindex* levels are then Huffman coded by the Huffman encoder 38. The resulting encoded data values are then

- 67 -

combined with the tokens in buffer 38A to form a decompressed data bit stream 39.

An essential part of this method is that the old frame present in the video encoder 31 is exactly the same as the old frame 40 present in the video decoder 32. This allows the decoder 32 to be able to correctly decode the encoded bit stream 39 due to the fact that the encoded bit stream contains differences between new and old images and due to the fact that parts of the new frame are not sent due to compression. An inverse quantizer 41 is therefore provided in the video encoder 31 to inverse quantize the *qindex* levels and to store the old frame as sent into old frame store 35 for future comparison with the next frame of the video input signal.

In the video decoder 32, the compressed data stream 39 is received by a buffer 42. The tokens are separated from the Huffman encoded *qindex* levels. The Huffman encoded *qindex* levels are supplied to a Huffman decoder 43, the output of which is supplied to an inverse quantizer 44. The output of the inverse quantizer 44 is written into old frame store 40 under the control of the comparison tree decoder 45. Comparison tree decoder 45 determines what is written into the old frame store 40, depending in part on the tokens received from buffer 42. Once a new frame of transformed data values is present in old frame store 40, an inverse wavelet transform 46 inverse transforms that frame of transformed data values into a corresponding video output signal. To prevent the inverse wavelet transform 46 from overwriting and therefore corrupting the contents of old frame store 40 when it reconstructs data values corresponding to the original new frame data values, an intermediate frame store 47 is maintained.

The octave one HHHG, HHGH, HHGG, and HHHH from Figure 25 are read from the old frame store 40 by the inverse wavelet transform 46 to perform the octave 1 inverse transform as described above. However, the resulting

- 68 -

octave 0 HH sub-band, output from the inverse wavelet transform 46 is now written to the intermediate frame store 47, so as not to corrupt the old frame store 40. For the octave 0 inverse wavelet transform, the HG, GH, and GG sub-bands are read from the old frame store 40, and the HH sub-band is read from the intermediate frame store 47, to complete the inverse wavelet transform.

When the second frame of compressed video data 39 is received by the video decoder 32, the tokens received by the comparison tree decoder 45 are related to the contents of the previous frame of video information contained in old frame store 40. Accordingly, the video decoder 32 can reconstruct the latest frame of video data using the contents of the frame store 40 and the data values encoded in the compressed data stream 39. This is possible because the compressed data stream contains all the information necessary for the video decoder 32 to follow the same traversal of the tree of the decomposition that the encoder used to traverse the tree in the generation of the compressed data stream. The video decoder 32 therefore works in lock step with the video encoder 31. Both the encoder 31 and the decoder 32 maintain the same mode at a corresponding location in the tree. When the encoder 31 determines a new mode, it incorporates into the compressed data stream 39 a corresponding token, which the video decoder 32 uses to assume that new mode.

Figure 37 illustrates the modes of operation of one possible embodiment of the present invention. To explain the operation of the video encoder 31 and the video decoder 32, an example is provided. The initial frame of the video sequence is processed by the video encoder 31 in still mode. Still mode has three sub-modes: STILL, VOID\_STILL, and LPF\_STILL. The low pass two-by-two blocks of data values of the decomposition cause the comparison tree encoder 36 of video encoder 31 to enter the LPF\_STILL sub-mode. In this sub-mode, the four data values of the two-by-two block are quantized but are not Huffman

- 69 -

encoded. Similarly, no token is generated. The successive low pass component two-by-two blocks of data values are successively quantized and output into the compressed data stream 39.

5       Next, the lowest frequency octave of one of the sub-bands is processed by the comparison tree encoder 36. This two-by-two block of data values corresponds with block HHHG illustrated in Figure 25. The four data values of this two-by-two block are tested against the threshold  
10 limit to determine if it is "interesting". If the two-by-two block HHHG is interesting, then a single bit token 1 is generated, as illustrated in Figure 37, the mode of the comparison tree encoder remains in STILL mode, and the four data values of the two-by-two block HHHG are  
15 successively quantized and encoded and output into the compressed data stream 39.

For the purposes of this example, block HHHG is assumed to be interesting. The tree structure of Figure 25 is therefore ascended to octave 0 two-by-two block  
20 HG#1. Because the comparison tree encoder 31 remains in the STILL mode, this block is encoded in the STILL mode. The four data values of block HG#1 are tested to determine whether or not they are interesting. This sequence of testing the successive blocks of the tree structure is  
25 repeated as described above.

After the traversal of the four octave 0 sub-blocks HG#1, HG#2, HG#3 and HG#4, the comparison tree encoder 36 proceeds in the tree structure to the two-by-two block of data values in octave 1, block HHGH. For purposes of this  
30 example, this two-by-two is non-interesting. After the comparison tree encoder 36 reads the four data values, the result of the threshold test indicates a non-interesting two-by-two block. As illustrated in Figure 37, the encoder 31 which is in the still mode now generates a  
35 single bit token 0 and the comparison tree encoder 36 enters the VOID\_STILL sub-mode. Although no additional information is output into the compressed data stream 39,

- 70 -

the comparison tree encoder 36 proceeds to write 0's into the four locations of the two-by-two block HHGH, as well as all the locations of the two-by-two blocks in the tree above the non-interesting two-by-two block HHGH. In the example of Figure 25, the comparison tree encoder 36 writes 0's into all the addresses of blocks HHGH, GH#1, GH#2, GH#3 and GH#4. This zeroing is performed because the video decoder 32 will not be receiving the data values corresponding to that tree. Rather, the video decoder 32 will be receiving only a non-interesting token, a single bit 0. The video decoder 32 will therefore write zeros into frame store 40 in the remainder of the corresponding tree. In order to make sure that both the video encoder 31 and the video decoder 32 have exactly the same old frame 35 and 40, the video encoder too must zero out those non-interesting blocks.

After the first frame of video data has been encoded and sent in STILL mode, the next frame of video data is processed by the video encoder 31. By default, the encoder now enters SEND mode. For lowpass frequency component two-by-two blocks, the video encoder 31 enters the LPF\_SEND mode as illustrated in Figure 37. The encoding of such a lowpass component two-by-two block corresponds with the encoding of two-by-two block HHHH in Figure 25. However, now the comparison tree encoder 36 has both a new frame in frame store 34 as well as an old frame in frame store 35. Accordingly, the comparison tree encoder 36 determines the arithmetic difference of the respective four data values in the new frame from the four data values in the old frame at the corresponding position and compares the sum of those differences with a compare threshold. The compare threshold, compare, is calculated from a base compare threshold "Bcompare" as in the case of the previous threshold which determines which blocks are interesting, similar to equations 60 and 61. If the sum of the differences is less than the compare threshold, then the video encoder 31 sends a single bit token 0 and

- 71 -

remains in the LPF\_SEND mode, as illustrated in Figure 37. The video encoder 31 does not transmit any data values corresponding to the lowpass frequency component two-by-two block.

5 If, on the other hand, the sum of the arithmetic differences exceeds the compare threshold, then a single bit token 1 is generated, as illustrated in Figure 37. In this case, the video encoder 31 sends the arithmetic differences of each of the successive four data values of  
10 the new frame versus the old frame to the quantizer 37 and then to the Huffman encoder 38. The arithmetic differences are encoded and sent rather than sending the actual data values because this results in fewer bits due to the fact that the two blocks in the new and old frames  
15 are quite similar under normal circumstances.

When the video encoder 31 proceeds to encode the octave 1 sub-band HHHG, as illustrated in Figure 25, the video encoder 31 enters the SEND mode, as illustrated in Figure 37. In this mode, the comparison tree encoder 36  
20 compares the data values of the new two-by-two block with the data values of the old two-by-two block and performs a series of arithmetic operations to generate a series of flags, as illustrated in Figure 38. Based on these flags, the video encoder 31 generates a 2-bit token and enters  
25 one of four new modes for that two-by-two block. If, for example, the two-by-two block HHHG in Figure 25 is received by the video encoder 31, then flags ozflag, nzflag, new\_z, noflag, motion, origin, and no\_z are determined. The values of these flags are determined as:

$$30 \quad nz = \sum_{x=0}^1 \sum_{y=0}^1 |new[x][y]| \quad (\text{equ. 62})$$

$$no = \sum_{x=0}^1 \sum_{y=0}^1 |new[x][y] - old[x][y]| \quad (\text{equ. 63})$$

$$oz = \sum_{x=0}^1 \sum_{y=0}^1 |old[x][y]| \quad (\text{equ. 64})$$

- 72 -

```

        nzflag = nz < limit                                (equ. 65)
        noflag = no < compare                              (equ. 66)
        origin = nz ≤ no                                    (equ. 67)
        motion = ((nz + oz) << oct) ≤ no                  (equ. 68)
5  new_z = |new[x][y]| < qstep , 0 ≤ x, y, ≤ 1           (equ. 69)
    no_z = |new[x][y] - old [x][y]| < qstep, 0 ≤ x, y ≤ 1 (equ. 70)
    ozflag = {old[x][y] = 0; for all 0 ≤ x, y ≤ 1}        (equ. 71)

```

Based on the values of these flags, the new mode for  
 10 the two-by-two block HHHG is determined, from Figure 38.

If the new mode is determined to be the SEND mode,  
 the 2-bit token 11 is sent as indicated in Figure 37. The  
 arithmetic differences of the corresponding four data  
 values are determined, quantized, Huffman encoded, and  
 15 sent into the compressed data stream 39.

In the case that the flags indicate the new mode is  
 STILL\_SEND, then the 2-bit token 01 is sent and the new  
 four data values of the two-by-two block are quantized,  
 Huffman encoded, and sent. Once having entered the  
 20 STILL\_SEND mode, the video encoder 31 remains in the  
 STILL\_SEND mode until the end of the tree has been  
 reached. In this STILL\_SEND mode, a single bit token of  
 either 1 or 0 precedes the encoding of each block of data  
 values. When the VOID mode is entered from STILL\_SEND  
 25 mode, the video encoder 31 generates a single bit 0 token,  
 then places zeros in the corresponding addresses for that  
 two-by-two block, and then proceeds to place zeros in the  
 addresses of data values of the two-by-two blocks in the  
 tree above.

30 In the event that the flags indicate that the video  
 encoder 31 enters the VOID mode from SEND mode, a 2-bit  
 token 10 is generated and the four data values of that  
 two-by-two block are replaced with zeros. The VOID mode  
 also results in the video encoder 31 placing zeros in all  
 35 addresses of all data values of two-by-two blocks in the  
 tree above.

In the case that the flags indicate that there is no



- 73 -

additional information in the tree being presently encoded, namely, the new and the old trees are substantially the same, then a 2-bit token of 00 is generated and the video encoder 31 proceeds to the next 5 tree in the decomposition.

In general, when the video encoder 31 enters VOID mode, the video encoder will remain in VOID mode until it determines that the old block already contains four zero data values. In this case, there is no reason to continue 10 in VOID mode writing zeros into that two-by-two block or the remainder of the blocks in the tree above because it is guaranteed that the old tree already contains zeros in these blocks. This is true because the old tree in frame store 35 has previously been encoded through the inverse 15 quantizer 41.

Because the video decoder 32 is aware of the tree structure of the decomposition, and because the video encoder 31 communicates with the video decoder 32 using tokens, the video decoder 32 is directed through the tree 20 structure in the same manner that the video encoder 31 traverses the tree structure in generating the compressed data stream 39. In this way the video decoder 32 writes the appropriate data values from the decompressed data stream 39 into the corresponding positions of the old data 25 frame 40. The only flag needed by the video decoder 32 is the ozflag, which the video decoder obtains by reading the contents of old frame store 40.

#### RATE CONTROL

All transmission media and storage media have a 30 maximum bandwidth at which they can accept data. This bandwidth can be denoted in terms of bits per second. A standard rate ISDN channel digital telephone line has, for example, a bandwidth of 64 kbits/sec. When compressing a sequence of images in a video sequence, depending upon the 35 amount of compression used to compress the images, there may be a relatively high number of bits per second

- 74 -

generated. This number of bits per second may in some instances exceed the maximum bandwidth of the transmission media or storage device. It is therefore necessary to reduce the bits per second generated to insure that the maximum bandwidth of the transmission media or storage device is not exceeded.

One way of regulating the number of bits per second introduced into the transmission media or storage device involves the use of a buffer. Frames having a high number of bits are stored in the frame buffer, along with frames having a low number of bits, whereas the number of bits per second passing out of the buffer and into the transmission media or storage device is maintained at a relatively constant number. If the buffer is sufficiently large, then it is possible to always achieve the desired bit rate as long as the overall average of bits per second being input into the buffer over time is the same or less than the maximum bit rate being output from the buffer to the transmission media or storage device.

There is, however, a problem associated with large buffers in video telephony. For a large buffer, there is a significant time delay between the time a frame of video data is input into the buffer and time when this frame is output from the video buffer and into the transmission media or storage device. In the case of video telephony, large buffers may result in large time delays between the time when one user begins to speak and the time when another user begins to hear that speech. This time delay, called latency, is undesirable. For this reason, buffer size is specified in the standard H.261 for video telephony.

In accordance with one embodiment of the present invention, a rate control mechanism is provided which varies the number of bits generated per frame, on a frame by frame basis. Due to the tree encoding structure described above, the number of bits output for a given frame is dependent upon the number of trees ascended in

- 75 -

the tree encoding process. The decisions of whether or not to ascend a tree are made in the lowest high frequency octaves of the tree structure. As can be seen from Figure 25, there are relatively few number of blocks in the lowest frequency of the sub-bands, as compared to the number of blocks higher up in the sub-band trees. Given a particular two-by-two block in the tree structure, it is possible to decrease the value of  $Q$  in the equation for the threshold *limit* until that particular block is determined to be "interesting". Accordingly, a particular  $Q$  is determined at which that particular block becomes interesting. This process can be done for each block in the lowest frequency HG, GH and GG sub-bands. In this way, a histogram is generated indicating a number of two-by-two blocks in the lowest frequency of the three sub-bands which become interesting at each particular value of  $Q$ .

From this histogram, a relationship is developed of the total number of two-by-two blocks in the lowest frequency of the three sub-bands which are interesting for a given value of  $Q$ . Assuming that the number of blocks in the lowest frequency octave of the three sub-bands which are interesting for a given value of  $Q$  is representative of the number of bits which will be generated when the tree is ascended using that given value of  $Q$ , it is possible to determine the value of  $Q$  at which a desired number of bits will be generated when that frame is coded with that value of  $Q$ . Furthermore, the greater the threshold is exceeded, the more bits may be needed to encode that tree. It is therefore possible to weight by  $Q$  the number of blocks which are interesting for a given value of  $Q$ . Finally, the  $Q$  values so derived should be averaged between frames to smooth out fluctuations.

The encoder model RM8 of the CCITT Recommendation H.261 is based on the DCT and has the following disadvantages. The rate control method used by RM8 is a linear feedback technique. Buffer fullness is

- 76 -

proportional to  $Q$ . The value of  $Q$  must be adjusted after every group of blocks (GOB) to avoid overflow or underflow effects. This means that parts of the image are transmitted at a different level quality from other parts.

5 During parts of the image where little change occurs,  $Q$  drops which can result in uninteresting areas being coded very accurately. The objects of interest are, however, usually the moving ones. Conversely, during the coding of areas of high activity,  $Q$  rises creating large errors in

10 moving areas. When this is combined with a block based transform, the errors can become visually annoying.

The method of rate control described in connection with one embodiment of the present invention uses one value of  $Q$  for the whole frame. The value of  $Q$  is only

15 adjusted between frames. All parts of an image are therefore encoded with the same value of  $Q$ . Moreover, because the tree structure allows a relatively few number of blocks to be tested to determine an estimate of the number of bits generated for a given frame, more

20 intelligent methods of varying  $Q$  to achieve an overall desired bit rate are possible than are possible with conventional compression/decompression techniques.

#### TREE BASED MOTION ESTIMATION

Figure 39 represents a black box 1 on a white

25 background 2. Figure 40 represents the same black box 1 on the same white background 2 moved to the right so that it occupies a different location. If these two frames of Figures 39 and 40 are encoded according to the above described method, there will be a tree in the wavelet

30 decomposition which corresponds with the white-to-black edge denoted 3 in Figure 39. Similarly, there will be another tree in the wavelet decomposition of the image of Figure 40 which represents the white-to-black edge 3' the wavelet decomposition of the image of Figure 40. All of

35 the data values corresponding to these two trees will be determined to be "interesting" because edges result in

- 77 -

interesting data values in all octaves of the decomposition. Moreover, due to the movement of the corresponding edge of black box 1, all the data values of the edges of both of these two trees will be encoded as  
5 interesting data values in the resulting compressed data stream. The method described above therefore does not take into account that it is the same data values representing the same white-to-black edge which is present in both images but which is just located at a different  
10 location.

Figure 41 is a one dimensional representation of an edge. The corresponding low path component data values are not illustrated in Figure 41. Data values 4, 5, 6, 7, 8, and 9 represent the "interesting" data values of Figure  
15 41 whereas the other data values have low data values which makes those blocks "non-interesting". In the representation of Figure 41, data values 4 and 5 are considered a single two data value block. Similarly, blocks 6 and 7 are considered a single block and blocks 8  
20 and 9 are considered a single block. Figure 41, although it is a one dimensional representation for ease of illustration, represents the edge 3 of the frame of Figure 39.

Figure 42 represents the edge 3' shown in Figure 40.  
25 Figure 42 indicates that the edge of black box 1 has moved in location due to the fact that the values 19 and 21 which in Figure 41 were in the two data value block 8 and 9 are located in Figure 42 in the two data value block 10 and 11. In the encoding of Figure 42, rather than  
30 encoding and sending into the compressed data stream the values 19 and 21, a control code is generated which indicates the new locations of the two values. Although numerous control codes are possible, only one embodiment is described here.

35 When the two data value block 10 and 11 is tested to determine whether it is interesting or not, the block tests to be interesting. The neighboring blocks in the

- 78 -

old frame are, however, also tested to determine whether the same values are present. In this case, the values 19 and 21 are determined to have moved one two data value block to the right. An "interesting with motion" token is therefore generated rather than a simple "interesting" token. A single bit 1 is then sent indicating that the edge represented by values 19 and 21 has moved to the right. Had the edge moved to the left, a control code of 0 would have been sent indicating that the edge represented by values 19 and 21 moved one location to the left. Accordingly, in the encoding of Figure 42, an "interesting with motion" token is generated followed by a single control code 1. The interesting values 19 and 21 therefore need not be included in the compressed data stream. The video decoder receiving this "interesting with motion" token and this control code 1 can simply copy the interesting values 19 and 21 from the old frame into the indicated new location for these values in the new frame obviating the need for the video encoder to encode and transmit the actual interesting data values themselves. The same token and control codes can be sent for the two data values corresponding to a block in any one of the octaves 0, 1 or 2.

Figure 43 represents the motion of the edge 3 of Figure 39 to a new location which is farther removed than is the new location of black box 1 shown in Figure 40. Accordingly, it is seen that the values 20 and 21 are located to the right at the two data value block 12 and 13. In the encoding of this two data value block 12 and 13 a token indicating "interesting with motion" is generated. Following that token, a control code 1 is generated indicating motion to the right. The video encoder therefore need not encode the data values 20 and 21 but merely needs to generate the interesting with motion token followed by the motion to the right control code. When the video encoder proceeds to the two data values block 14 and 15, the video encoder need not send

- 79 -

the "interesting with motion" token but rather only sends the left control code 0. Similarly, when the video encoder proceeds to encode the two data value block 16 and 17, the video encoder only sends the left control code 0.

5 The control codes for octaves 0 and 1 do not denote motion per se but rather denote left or right location above a lower frequency interesting block of the moving edge. This results in the video encoder not having to encode any of the actual data values representing the moved edge in

10 the decomposition of Figure 43.

The one dimensional illustration of Figures 41, 42 and 43 is presented for ease of illustration and explanation. It is to be understood, however, that this method of indicating edge motion is used in conjunction

15 with the above described two dimensional wavelet decomposition such as the two dimensional wavelet decomposition illustrated in Figure 25. The video encoder searches for movement of the data values representing an edge only by searching the nearest neighboring blocks of

20 data values in the old frame. This method can be used to search many neighbors or a few neighbors depending on the application. The counter scheme described in connection with Figures 27 and 28 can be used to determine the locations of those neighboring blocks. Although the edge

25 motion illustrated in connection with Figures 41, 42, and 43 shows the very same data values being moved in the tree structure of the decomposition, it is to be understood that in practice the values of the data values representing the same edge may change slightly with the

30 movement of the edge. The video encoder takes this into account by judging corresponding data values using a motion data value threshold to determine if corresponding data values in fact do represent the same edge. By indicating edge motion and not sending the edge data

35 values themselves it is possible to both increase the compression and also improve the quality of the decompressed image.

- 80 -

## SIX COEFFICIENT QUASI-DAUBECHIES FILTERS

The Daubechies six coefficient filters are defined by the six low pass filter coefficients, listed in the table below to 8 decimal places. The coefficients are also defined in terms of four constants,  $\alpha$ ,  $\beta$ ,  $\gamma$  and  $\epsilon$ , where  $\alpha = 0.10588942$ ,  $\beta = -0.54609641$ ,  $\gamma = 2.4254972$  and  $\epsilon = 3.0059769$ .

	Daubechies coefficients	Alternative representation	Normalized coefficients	Converted Coefficients
10	a	$1/\epsilon$	0.2352336	$\frac{30}{128}$
	b	$\gamma/\epsilon$	0.57055846	$\frac{73}{128}$
	c	$-\beta(\alpha+\gamma)/\epsilon$	0.3251825	$\frac{41}{128}$
	-d	$\beta(1 - \alpha\gamma)/\epsilon$	-0.095467208	$\frac{-12}{128}$
	-e	$-\alpha\gamma/\epsilon$	-0.060416101	$\frac{-7}{128}$
	f	$\alpha/\epsilon$	0.024908749	$\frac{3}{128}$

Table 4

15 The coefficients (a, b, c, -d, -e, f) sum to  $\sqrt{2}$ . The normalized coefficients sum to 1, which gives the filter the property of unity gain, which in terms of the alternative representation is equivalent to a change in the value of  $\epsilon$  to 4.2510934. These values can be approximated to any given precision by a set of fractions. In the example shown above, each of the normalized values has been multiplied by 128 and rounded appropriately, thus the coefficient a has been converted to  $\frac{30}{128}$ . Filtering is therefore possible using integer multiplications rather than floating point arithmetic. This greatly reduces implementation cost in terms of digital hardware gate count and computer software speed. The following equations show a single step in the filtering process, the outputs H and G being the low and high pass outputs, respectively:

$$H_1 = aD_0 + bD_1 + cD_2 - dD_3 - eD_4 + fD_5 \quad (\text{equ. } 72)$$



- 81 -

$$G_1 = -fD_0 - eD_1 + dD_2 + cD_3 - bD_4 + aD_5 \quad (\text{equ. 73})$$

$H_1$  and  $G_1$  are calculated as follows. Each data value  $D$  is multiplied by the relevant integer numerator (30, 73, 41, 12, 7, 3) and summed as shown. The values of  $H$  and  $G$  are found by dividing the summations by the constant 128. Because 128 is an integer power of 2, the division operation requires little digital hardware to implement and only simple arithmetic shift operations to implement in software. The filters  $H$  and  $G$  are quasi-perfect reconstruction filters:

$$a+b+c-d-e+f=1 \quad (\text{equ. 74})$$

$$-f-e+d+c-b+a=0 \quad (\text{equ. 75})$$

$$a+c-e = \frac{1}{2} \quad (\text{equ. 76})$$

$$f-d+b = \frac{1}{2} \quad (\text{equ. 77})$$

Equation 74 guarantees unity gain. Equation 75 guarantees that the high pass filter will generate zero for a constant input signal. Equations 76 and 77 guarantee that an original signal once transferred can be reconstructed exactly.

The following equations show a single step in the inverse transformation:

$$D_2 = 2(-eH_0 - bG_0 + cH_1 + dG_1 + aH_2 - fG_2) \quad (\text{equ. 78})$$

$$D_3 = 2(fH_0 + aG_0 - dH_1 + cG_1 + bH_2 - eG_2) \quad (\text{equ. 79})$$

As for the forward filtering process, the interleaved  $H$  and  $G$  data stream is multiplied by the relevant integer numerator and summed as shown. The output  $D$  data values are found by dividing the summations by the constant 64, which is also an integer power of 2.

To calculate the first and last  $H$  and  $G$  values, the filter equations must be altered such that values outside the boundaries of the data stream are not required. For example, if  $H_0$  is to be calculated using the six coefficient filter, the values  $D_{-1}$  and  $D_{-2}$  would be required. Because

- 82 -

these values are not defined, a different filter is used at the beginning and end of the data stream. The new filters are determined such that the reconstruction process for the first and last two data values is possible. The following 5 pair of equations show the filter used to calculate the first H and G values:

$$H_0 = cD_0 - dD_1 - eD_2 + fD_3 \quad (\text{equ. 80})$$

$$G_0 = dD_0 + cD_1 - bD_2 + aD_3 \quad (\text{equ. 81})$$

The last H and G values are calculated with:

$$10 \quad H_3 = aD_3 + bD_2 + cD_1 - dD_0 \quad (\text{equ. 82})$$

$$G_3 = fD_3 - eD_2 + dD_1 + cD_0 \quad (\text{equ. 83})$$

In this case, these equations are equivalent to using the non-boundary equations with data values outside the data stream being equal to zero. The following inverse 15 transform boundary filters are used to reconstruct the first two and last two data values:

$$D_0 = 2 \left( \left( c - \frac{b}{\beta} \right) H_0 + \left( d + \frac{e}{\beta} \right) G_0 + aH_1 - fG_1 \right) \quad (\text{equ. 84})$$

$$D_1 = 2 \left( \left( \frac{a}{\beta} - d \right) H_0 + \left( c - \frac{f}{\beta} \right) G_0 + bH_1 - eG_1 \right) \quad (\text{equ. 85})$$

$$D_A = 2 \left( -eH_4 - bG_4 + \left( c - \frac{f}{\beta} \right) H_5 + \left( d - \frac{a}{\beta} \right) G_5 \right) \quad (\text{equ. 86})$$

$$D_B = 2 \left( fH_4 + aG_4 - \left( d + \frac{e}{\beta} \right) H_5 + \left( c - \frac{b}{\beta} \right) G_5 \right) \quad (\text{equ. 87})$$

#### INCREASING SOFTWARE DECOMPRESSION SPEED

A system is desired for compressing and decompressing video using dedicated digital hardware to compress and 20 using software to decompress. For example, in a video mail application one user uses a hardware compression expansion card for an IBM PC personal computer coupled to a video camera to record a video message in the form of a video message file. This compressed video message file is then 25 transmitted via electronic mail over a network such as a hardwired network of an office building. A recipient user receives the compressed video message file as he/she would receive a normal mail file and then uses the software to

- 83 -

decompress the compressed video message file to retrieve the video mail. The video mail may be displayed on the monitor of the recipient's personal computer. It is desirable to be able to decompress in software because  
5 decompressing in software frees multiple recipients from purchasing relatively expensive hardware. Software for performing the decompression may, for example, be distributed free of charge to reduce the cost of the composite system.

10 In one prior art system, the Intel Indeo video compression system, a hardware compression expansion card compresses video and a software package is usable to decompress the compressed video. This system, however, only achieves a small compression ratio. Accordingly,  
15 video picture quality will not be able to be improved as standard personal computers increase in computing power and/or video bandwidth.

The specification above discloses a method and apparatus for compressing and decompressing video. The  
20 software decompression implementation written in the programming language C disclosed in Appendix A only decompresses at a few frames per second on a standard personal computer at the present date. A method capable of implementation in software which realizes faster  
25 decompression is therefore desirable.

A method for decompressing video described above is therefore modified to increase software execution speed. Although the  $b=19/32$ ,  $a=11/32$ ,  $c=5/32$  and  $d=3/32$  coefficients used to realize the high and low pass forward  
30 transform perfect reconstruction digital filters are used by dedicated hardware to compress in accordance with an above described method, the coefficients  $b=5/8$ ,  $a=3/8$ ,  $c=1/8$  and  $d=1/8$  are used to decompress in software on a digital computer. The coefficients are determined as shown  
35 in the table below.

- 84 -

$$\begin{aligned}
 a &= \frac{1+\sqrt{3}}{8} \approx .3415(8) = 2.732 \approx \frac{3}{8} \\
 b &= \frac{3+\sqrt{3}}{8} \approx .5915(8) = 4.732 \approx \frac{5}{8} \\
 c &= \frac{3-\sqrt{3}}{8} \approx .1585(8) = 1.268 \approx \frac{1}{8} \\
 d &= \frac{-1+\sqrt{3}}{8} \approx .0915(8) = 0.732 \approx \frac{1}{8}
 \end{aligned}$$

5

Table 5

An even start inverse transform digital filter in accordance with the present embodiment is:

$$D_0 = 4[(b-a)H_0 + (c-d)G_0] \quad (\text{equ. 88})$$

where, for example,  $D_0$  is a first inverse transformed data value indicative of a corresponding first data value of a row of the original image, and where  $H_0$  and  $G_0$  are first low and high pass component transformed data values of a row of a sub-band decomposition.

An odd end inverse transform digital filter in accordance with the present embodiment is:

$$D_B = 4[(c+d)H_s - (a+b)G_s] \quad (\text{equ. 89})$$

where, for example,  $D_B$  is a last inverse transformed data value indicative of a corresponding last data value of a row of the original image, and where  $H_s$  and  $G_s$  are last low and high pass component transformed data values of a row of a sub-band decomposition.

An odd interleaved inverse transform digital filter in accordance with the present embodiment is:

$$\frac{D(2x-1)}{2} = \frac{1}{8}H(x-1) - \frac{5}{8}G(x-1) + \frac{3}{8}H(x) + \frac{1}{8}G(x) \quad (\text{equ. 90})$$

25 An even interleaved inverse transform digital filter in accordance with the present embodiment is:

$$\frac{D(2x)}{2} = -\frac{1}{8}H(x-1) + \frac{3}{8}G(x-1) + \frac{5}{8}H(x) + \frac{1}{8}G(x) \quad (\text{equ. 91})$$

As indicated by equations 90 and 91, the odd and even interleaved inverse transform digital filters operable on

- 85 -

the same H and G values of the sub-band decomposition but generate the odd and even inverse transformed data values in a row between the even start and odd end filters of equations 88 and 89.

5       Using the above even start, odd end, odd interleaved and even interleaved inverse transform digital filters, a frame rate of approximately 15 frames/second is realizable executing on a Macintosh Quadra personal computer having a 68040 microprocessor. Digital filters using the  
10 coefficients  $b=5/8$ ,  $a=3/8$ ,  $c=1/8$  and  $d=1/8$  may also be realized in dedicated digital hardware to reduce the cost of a dedicated hardware implementation where a slightly lower compression ratio is acceptable.

To further increase software decompression speed when  
15 decompressing video on a digital computer, only two octaves of inverse transform are performed on video which was previously compressed using three octaves of forward transform. This results in the low pass component of the octave 0 decomposition. The low pass component of the  
20 octave 0 decomposition is a non-aliased high quality quarter size decimated version of the original image. Rather than performing octave 0 of inverse transform, horizontal linear interpolation is used to expand each row of data values of the low pass component of the octave 0  
25 decomposition into twice the number of data values. To expand the number of rows, each row of interpolated data values is replicated once so that the total number of rows is doubled. In some embodiments, interpolation techniques other than linear interpolation are used to improve image  
30 quality. For example, spline interpolation or polynomial interpolation may be used.

To further increase software execution speed when decompressing video, luminance data values are decompressed using the digital filters of equations 88, 89, 90 and 91.  
35 The chrominance data values, on the other hand, are decompressed using even and odd interleaved reconstruction filters having a fewer number of coefficients than four.

- 86 -

In one embodiments, two coefficient odd interleaved Haar and even interleaved Haar filters are used. The even interleaved Haar reconstruction filter is:

$$D_0 = (H_0 + G_0) \quad (\text{equ. 92})$$

5 The odd interleaved Haar reconstruction filter is:

$$D_1 = (H_0 - G_0) \quad (\text{equ. 93})$$

Because the above Haar filters each only have two coefficients, there is no boundary problem as is addressed in connection with an above-described method. Accordingly,  
10 another start inverse transform digital filter and another end inverse transform digital filter are not used.

To increase software execution speed still further when decompressing video, variable-length SEND and STILL\_SEND tokens are used. Data values are encoded using  
15 a Huffman code as disclosed above whereas tokens are generated in variable-length form and appear in this variable-length form in the compressed data stream. This allows decompression to be performed without first calculating flags.

20 Figure 44 shows variable-length tokens used for encoding and decoding in accordance with some embodiments of the present invention. Because transitions from SEND mode to STOP mode or from STILL\_SEND mode to STOP mode occur most frequently of the transitions indicated in  
25 Figure 44, the corresponding tokens consist of only one bit.

In general, if an area changes from white to black in two consecutive frames of a video sequence and if the encoder is in LPF\_SEND mode, then the difference between  
30 the corresponding data values after quantization will be much larger than 37. 37 is the maximum number encodable using the specific Huffman code set forth in connection with an above-described method. Because such a large

- 87 -

change in data value cannot be encoded, an artifact will be generated in the decompressed image for any change in quantized data values exceeding 37. Accordingly, the Huffman code in the table below is used in accordance with one embodiment of the present invention.

	HUFFMAN CODE	qindex
	0	0
	1s1	±1
	1s01	±2
10	1s001	±3
	1s0001	±4
	1s00001	±5
	1s000001	±6
	1s0000001	±7
15	1s0000000 ( $ qindex  - 8$ )	±8 . . ±135

Table 6

In Table 6 above, the value ( $|qindex| - 8$ ) is seven bits in length. The s in Table 6 above is a sign bit.

This embodiment is not limited to video mail applications and is not limited to systems using dedicated hardware to compress and software executing on a digital computer to decompress. Digital circuitry of a general purpose digital computer having a microprocessor may be used to decode and inverse transform a compressed image data stream. The coefficients  $5/8$ ,  $3/8$ ,  $1/8$  and  $1/8$  independent of sign may be the four coefficients of four coefficient high and low pass forward transform perfect reconstruction digital filters used to transform image data values into a sub-band decomposition.

- 88 -

Although the present invention has been described by way of the above described specific embodiments, it will be understood that certain adaptations, modifications, rearrangements and combinations of various features of the 5 specific embodiments may be practiced without departing from the scope of the invention. Filters other than the four coefficient quasi-Daubechies filters can be used. In some embodiments, six coefficient quasi-Daubechies filters are used. Embodiments of this invention may, for example, 10 be practiced using a one-dimensional tree structure, a two-dimensional tree structure, or a three-dimensional tree structure. Rather than testing whether or not a two-by-two block of data values is interesting, blocks of other sizes may be used. Three-by-three blocks of data values may, for 15 example, be tested. Blocks of different sizes may be used in different octaves of a decomposition. In certain embodiments, there are different types of interesting blocks. The use of tokens in combination with use of a tree structure of a decomposition to reduce the number of 20 data values encoded may be extended to include other tokens having other meanings. The "interesting with motion" token is but one example. Tree structures may be used in numerous ways to estimate the activity of a frame for rate control purposes. Numerous boundary filters, thresholds, 25 encoder and decoder modes, token schemes, tree traversing address generators, quantization schemes, Huffman-like codes, and rate control schemes will be apparent from the specific embodiments. The above-described specific embodiments are therefore described for instructional 30 purposes only and are not intended to limit the invention as set forth in the appended claims.



DATA COMPRESSION AND DECOMPRESSION  
GREGORY KNOWLES AND ADRIAN S. LEWIS  
M-2357 US  
APPENDIX A

- 90 -

source/Bits.c

```
/*
    Reading and writing bits from a file
*/

#include    "../include/xwave.h"
#include    "../include/Bits.h"

Bits  bopen(name,mode)

String name, mode;

{
    Bits  bits=(Bits)MALLOC(sizeof(BitsRec));

    if((bits->fp=fopen(name,mode))==(FILE*)0)Eprintf("Failed to open binary
file\n");    /*change*/
    bits->bufsize=0;    /*new*/
    bits->buf=(unsigned char)0;    /*new*/
    return(bits);
}

void  bclose(bits)

Bits  bits;

{
    if(fclose(bits->fp)!=0) Eprintf("Failed to close binary file\n"); /*was:
fclose(bits->fp)*/
```

- 91 -

```

        XtFree(bits);
    }

void bread(bytes,num,bits)

unsigned char    *bytes;
int    num;
Bits    bits;

{
    int    byte=0, bit=0,pull,b;

    bytes[byte]=0;
    while(num>0) {
        if (bits->bufsize==0) {
            pull=fgetc(bits->fp);
            if(pull==EOF)
            {
                /*printf("EOF\n"); Previously didn't check for
EOF:bits->buf=(unsigned char)fgetc(bits->fp)*/
                for(b=byte+1;b<num/8+1;b++)
                    bytes[b]=(unsigned char)0;
                return;
            }
            bits->buf=(unsigned char)pull;
            bits->bufsize=8;
        }

        bytes[byte]=((1&bits->buf)!=0)?bytes[byte]|(1<<bit):bytes[byte]&~(1<<bit);
        if (bit==7) { bit=0; byte++; bytes[byte]=0; } /* was bit==8 */
        else bit++;
        bits->buf=bits->buf>>1;
    }
}

```

- 92 -

```
        bits->bufsize--;  
        num--;  
    }  
}  
  
void  bwrite(bytes,num,bits)  
  
unsigned char    *bytes;  
int    num;  
Bits    bits;  
  
{  
    int    byte=0, bit=0;  
    unsigned char    xfer;  
  
    while(num>0) {  
        if (bit==0) {  
            xfer=bytes[byte++];
```

- 93 -

source/Color.c

```
/*
 *   Color routines
 */

#include    "../include/xwave.h"
#define    GAMMA    1.0/2.2

int
VisualClass[6] = {PseudoColor, DirectColor, TrueColor, StaticColor, GrayScale, StaticGray};

/*   Function Name:    Range
 *   Description:    Range convert for RGB/YUV calculations
 *   Arguments:    old_x - old value (0..old_r-1)
 *                old_r - old range < new_r
 *                new_r - new range
 *   Returns:    old_x scaled up to new range
 */

int    Range(old_x, old_r, new_r)

int    old_x, old_r, new_r;

{
    return((old_x*new_r)/old_r);
}

/*   Function Name:    Gamma
 *   Description:    Range convert with Gamma correction for RGB/YUV calculations
 *   Arguments:    as Range +
 *                factor - gamma correction factor
```

- 94 -

```

*   Returns:      old_x gamma corrected and scaled up to new range
*/

int   Gamma(old_x,old_r,new_r,factor)

int   old_x, old_r, new_r;
double      factor;

{
    return((int)((double)new_r*pow((double)old_x/(double)old_r,factor)));
}

/*   Function Name:      Dither
*   Description:  Range convert with dithering for RGB/YUV calculations
*   Arguments:  levels - output range (0..levels-1)
*               pixel - pixel value (0..1 < < 8+precision-1)
*               x, y - dither location
*               precision - pixel range (0..1 < < 8+precision-1)
*   Returns:      dithered value (0..levels-1)
*/

int   Dither(levels,pixel,x,y,precision)

int   pixel, levels, x, y, precision;

{
    int   bits=8+precision,
          pixlev=pixel*levels,

value=(pixlev >> bits)+((pixlev-(pixlev&(-1 < < bits)))>> precision > global-> dither[x
&15][y&15]?1:0);

```

- 95 -

```

    return(value >= levels?levels-1:value);
}

```

```

/*  Function Name:    ColCvt
 *
 *  Description:    Converts between RGB and YUV triples
 *
 *  Arguments:    src - source triple
 *
 *                dst - destination triple
 *
 *                rgb_yuv - convert direction RGB->YUV True
 *
 *                max - range of data (max-1...-max)
 *
 *  Returns:      alters dst.
 */

```

```

void  ColCvt(src,dst,rgb_yuv,max)

```

```

short  src[3], dst[3];

```

```

Boolean    rgb_yuv;

```

```

int    max;

```

```

{
    double    rgb_yuv_mat[2][3][3]={
        {0.299,0.587,0.114},
        {-0.169,-0.3316,0.5},
        {0.5,-0.4186,-0.0813}
    },{
        {1,0,1.4021},
        {1,-0.3441,-0.7142},
        {1,1.7718,0}
    }
};
    int    i, channel;

    for(channel=0;channel<3;channel++) {

```

- 96 -

```

double      sum=0.0;

    for(i=0;i<3;i++)
sum+=(double)(src[i])*rgb_yuv_mat[rgb_yuv?0:1][channel][i];
    dst[channel]=(int)sum<-max?-max:(int)sum>max-1?max-1:(short)sum;
    }
}

```

```

/*  Function Name:    CompositePixel
*   Description:    Calculates pixel value from components
*   Arguments:    frame - Frame to be drawn on
*                  x, y - coordinate of pixel in data
*                  X, Y - coordinate of pixel in display
*   Returns:    pixel value in colormap
*/

```

```

int  CompositePixel(frame,x,y,X,Y)

```

```

Frame frame;

```

```

int  x, y, X, Y;

```

```

{

```

```

    Video vid=frame->video;

```

```

    int  channel=frame->channel, pixel, value=0;

```

```

    if (channel!=3) {

```

```

pixel=(int)vid->data[channel][frame->frame][Address2(vid,channel,x,y)]+(128<<vid-
>precision);

```

```

    value=Dither(global->levels,pixel,X,Y,vid->precision);

```

```

    } else for(channel=0;channel<3;channel++) {

```

```

        int

```



- 97 -

```

levels=vid->type==RGB?global->rgb_levels:global->yuv_levels[channel];

pixel=(int)vid->data[channel][frame->frame][Address(vid,channel,x,y)]+(128<<vid-
>precision),
        value=levels*value+Dither(levels,pixel,X,Y,vid->precision);
    }
    return(value);
}

```

```

void InitVisual()

{
    Display      *dpy=XtDisplay(global->toplevel);
    int    scrn=XDefaultScreen(dpy), class=0, depth=8, map, i, r, g, b, y, u, v;
    String
VisualNames[6]={ "PseudoColor", "DirectColor", "TrueColor", "StaticColor", "GrayScale",
"StaticGray"};
    XColor      color;

    global->visinfo=(XVisualInfo *)MALLOC(sizeof(XVisualInfo));
    while(depth>0
&&!XMatchVisualInfo(dpy,scrn,depth,VisualClass[class],global->visinfo))
        if (class==5) {class=0; depth--;} else class++;
    Dprintf("Visual: %s depth %d\n",VisualNames[class],depth);
    global->palettes=(Palette)MALLOC(sizeof(PaletteRec));
    strcpy(global->palettes->name,"Normal");
    global->palettes->next=NULL;
    global->no_pals=1;
    switch(global->visinfo->class) {
    case TrueColor:
    case DirectColor:

```

- 98 -

```

case StaticColor:
case GrayScale:
    fprintf(stderr, "Unsupported visual type: %s\n", VisualNames[class]);
    exit();
    break;
case PseudoColor:
    global->levels=global->visinfo->colormap_size;
    global->rgb_levels=(int)pow(((double)global->levels,1.0/3.0);
    for(map=0;map<2;map++) { /* rgb non-gamma and gamma maps */

global->cmaps[map]=XCreateColormap(dpy,XDefaultRootWindow(dpy),global->visinfo
->visual,AllocAll);
        for(r=0;r<global->rgb_levels;r++)
            for(g=0;g<global->rgb_levels;g++)
                for(b=0;b<global->rgb_levels;b++) {

color.pixel=(r*global->rgb_levels+g)*global->rgb_levels+b;

color.red=(map&1)?Gamma(r,global->rgb_levels,65536,GAMMA):Range(r,global->rg
b_levels,65536);

color.green=(map&1)?Gamma(g,global->rgb_levels,65536,GAMMA):Range(g,global->
rgb_levels,65536);

color.blue=(map&1)?Gamma(b,global->rgb_levels,65536,GAMMA):Range(b,global->r
gb_levels,65536);

            color.flags=DoRed | DoGreen | DoBlue;

XStoreColor(dpy,global->cmaps[map],&color);
        }
        color.pixel=global->levels-1;
        color.red=255<<8;

```

- 99 -

```

        color.green=255 << 8;
        color.blue=255 << 8;
        color.flags=DoRed | DoGreen | DoBlue;
        XStoreColor(dpy,global->cmaps[map],&color);
    }
    for(map=2;map<4;map++) { /* mono non-gamma and gamma maps */

global->cmaps[map]=XCreateColormap(dpy,XDefaultRootWindow(dpy),global->visinfo
->visual,AllocAll);

        for(i=0;i<global->visinfo->colormap_size;i++) {
            color.pixel=i;

color.red=(map&1)?Gamma(i,global->levels,65536,GAMMA):Range(i,global->levels,6
5536);

color.green=(map&1)?Gamma(i,global->levels,65536,GAMMA):Range(i,global->levels
,65536);

color.blue=(map&1)?Gamma(i,global->levels,65536,GAMMA):Range(i,global->levels,
65536);

            color.flags=DoRed | DoGreen | DoBlue;
            XStoreColor(dpy,global->cmaps[map],&color);
        }
    }

    global->yuv_levels[0]=(int)pow((double)global->levels,1.0/2.0);
    global->yuv_levels[1]=(int)pow((double)global->levels,1.0/4.0);
    global->yuv_levels[2]=(int)pow((double)global->levels,1.0/4.0);
    for(map=4;map<6;map++) { /* yuv non-gamma and gamma maps */

global->cmaps[map]=XCreateColormap(dpy,XDefaultRootWindow(dpy),global->visinfo
->visual,AllocAll);

        for(y=0;y<global->yuv_levels[0];y++)

```

- 100 -

```

        for(u=0;u<global->yuv_levels[1];u++)
            for(v=0;v<global->yuv_levels[2];v++) {
                short
src[3]={{(short)(Range(y,global->yuv_levels[0],65536)-32768),
(short)(Range(u,global->yuv_levels[1],65536)-32768),
(short)(Range(v,global->yuv_levels[2],65536)-32768)}, dst[3];

                ColCvt(src,dst,False,65536/2);

color.pixel=(y*global->yuv_levels[1]+u)*global->yuv_levels[2]+v;

color.red=(map&1)?Gamma((int)dst[0]+32768,65536,65536,GAMMA):(int)dst[0]+32768;

color.green=(map&1)?Gamma((int)dst[1]+32768,65536,65536,GAMMA):(int)dst[1]+32768;

color.blue=(map&1)?Gamma((int)dst[2]+32768,65536,65536,GAMMA):(int)dst[2]+32768;

                color.flags=DoRed | DoGreen | DoBlue;

XStoreColor(dpy,global->cmaps[map],&color);
            }
        color.pixel=global->levels-1;
        color.red=255<<8;
        color.green=255<<8;
        color.blue=255<<8;
        color.flags=DoRed | DoGreen | DoBlue;
        XStoreColor(dpy,global->cmaps[map],&color);
    }

```

- 101 -

```

        global->palettes->mappings=NULL;
        break;
    case StaticGray:
        global->levels=1<<depth;
        for(i=0;i<6;i++) global->cmaps[i]=XDefaultColormap(dpy,scrn);
        color.pixel=0;
        XQueryColor(dpy,XDefaultColormap(dpy,scrn),&color);
        if (color.red==0 && color.green==0 && color.blue==0)
            global->palettes->mappings=NULL;
        else {
            global->palettes->mappings=(Map)MALLOC(sizeof(MapRec));
            global->palettes->mappings->start=0;
            global->palettes->mappings->finish=global->levels-1;
            global->palettes->mappings->m=-1;
            global->palettes->mappings->c=global->levels-1;
            global->palettes->mappings->next=NULL;
        }
        break;
    }
}

```

Colormap    ChannelCmap(channel,type,gamma)

```

int    channel;
VideoFormat type;
Boolean    gamma;

{
    Colormap    cmap;

    if (channel!=3 || type==MONO) {
        if (gamma) cmap=global->cmaps[global->cmaps[2]==NULL?3:2];
    }
}

```

- 102 -

```
        else cmap=global->cmaps[global->cmaps[3]==NULL?2:3];
    } else if (type==RGB) {
        if (gamma) cmap=global->cmaps[global->cmaps[0]==NULL?1:0];
        else cmap=global->cmaps[global->cmaps[1]==NULL?0:1];
    } else {
        if (gamma) cmap=global->cmaps[global->cmaps[4]==NULL?5:4];
        else cmap=global->cmaps[global->cmaps[5]==NULL?4:5];
    }
    return(cmap);
}
```

- 103 -

source/Convert.c

```
#include    "../include/xwave.h"

short  cti(c)

char  c;

{
    return((short)(c)^-128);
}

char  itc(i)

short  i;

{
    static int    errors=0;
    if (i<-128 || i>127) {
        if (errors==99) {
            Dprintf("100 Conversion overflows\n");
            errors=0;
        } else errors++;
        i=(i<-128)?-128:127;
    }
    return((char)(i^128));
}
```

- 104 -

**source/Convolve3.c**

```
/*
    2D wavelet transform convolver (fast hardware emulation)
    New improved wavelet coeffs : 11 19 5 3
*/

#include    "../include/xwave.h"

/*    Function Name:    Round
 *    Description:    Rounding to a fixed number of bits, magnitude rounded down
 *    Arguments:    number - number to be rounded
 *                   bits - shifted bits lost from number
 *    Returns:    rounded number
 */

short Round(number,bits)

int    number;
int    bits;

{
    if (bits==0) return((short)number);
    else return((short)(number+(1<<bits-1)-(number<0?0:1)>>bits));
}

/*    Function Name:    Convolve
 *    Description:    Perform a wavelet convolution on image data
 *    Arguments:    data - data to be transformed
 *                   dirn - convolution direction
```



- 105 -

```

*           size - size of image data
*           oct_src, oct_dst - initial and final octave numbers
*   Returns:   data altered
*/

```

```
void Convolve(data,dirn,size,oct_src,oct_dst)
```

```
short *data;
```

```
Boolean   dirn;
```

```
int   size[2], oct_src, oct_dst;
```

```
{
```

```
    int   tab[4][4], addr[4]={-1,-1,-1,-1}, index, mode, i, j, oct, orient,
area=size[0]*size[1];
```

```
    Boolean   fwd_rev=oct_src<oct_dst;
```

```
    int   windows[12][5]={
        {1,2,3,-4,2}, /* 0 - normal forward 0 */
        {4,-3,2,1,3}, /* 1 - normal forward 1 */
        {1,-2,3,4,2}, /* 2 - normal reverse 0 */
        {4,3,2,-1,3}, /* 3 - normal reverse 1 */
        {2,3,4,-4,3}, /* 4 - end forward 0 */
        {4,-4,3,2,4}, /* 5 - end forward 1 */
        {2,2,3,-4,2}, /* 6 - start forward 0 */
        {4,-3,2,2,3}, /* 7 - start forward 1 */
        {3,-4,-4,3,4}, /* 8 - break reverse end dirn==False*/
        {4,3,-3,-4,3}, /* 9 - break reverse start dirn==False */
        {-3,-4,4,3,4}, /* 10 - break reverse end dirn==True */
        {-4,3,3,-4,3}, /* 11 - break reverse start dirn==True */
    }, win[3];           /* 12 - no calculation */
```

```
    for(oct=oct_src;oct!=oct_dst;oct+=(fwd_rev?1:-1)) {
```

```
        long   shift=oct-(fwd_rev?0:1);
```

- 106 -

```

for(orient=0;orient<2;orient++) {
    Boolean    x_y=fwd_rev==(orient==0);

for (index=0;index<(area>>(shift<<1));index++) {
    long    major, minor, value, valuex3, valuex11, valuex19, valuex5;

    major=index/(size[x_y?0:1]>>shift);
    minor=index-major*(size[x_y?0:1]>>shift);
    for(j=0;j<3;j++) win[j]=12;
    switch(minor) {
    case 0: break;
    case 1: if (!fwd_rev) win[0]=dirn?11:9; break;
    case 2: if (fwd_rev) { win[0]=6; win[1]=7; }; break;
    default:
        if (minor+1==size[x_y?0:1]>>shift) {
            if (fwd_rev) { win[0]=4; win[1]=5; }
            else { win[0]=2; win[1]=3; win[2]=dirn?10:8; }
        } else if (fwd_rev) {
            if ((1&minor)==0) { win[0]=0; win[1]=1; }
        } else {
            if ((1&minor)!=0) { win[0]=2; win[1]=3; }
        }
    }

    addr[3&index]=(x_y?minor:major)+size[0]*(x_y?major:minor)<<shift;
    value=(int)data[addr[3&index]];

    valuex5=value+(value<<2);
    valuex3=value+(value<<1);
    valuex11=valuex3+(value<<3);
    valuex19=valuex3+(value<<4);
    tab[3&index][3]=fwd_rev || !dirn?valuex3:valuex19;
    tab[3&index][2]=fwd_rev || dirn?valuex5:valuex11;

```

- 107 -

```
tab[3&index][1]=fwd_rev || !dirn?valuex19:valuex3;
tab[3&index][0]=fwd_rev || dirn?valuex11:valuex5;
for(j=0;j<3 && win[j]!=12;j++) {
    int    conv=0;

    for(i=0;i<4;i++) {
        int    wave=dirn?3-i:i;

conv += negif(0> windows[win[j]][wave], tab[3&index+abs(windows[win[j]][i])][wave]);
    }

data[addr[3&index+ windows[win[j]][4]]]=Round(conv, fwd_rev?5:win[j]>7?3:4);
    }
    }}}
}
```

**source/Copy.c**

```
/*
    Copy video, includes direct copy, differencing, LPF zero, LPF only, RGB-YUV
    conversion and gamma correction
*/

#include    "../include/xwave.h"
#include    "Copy.h"
extern int  Shift();
extern void ColCvt();

void  CopyVideoCtrl(w,closure,call_data)

Widget      w;
caddr_t closure, call_data;

{
    CopyCtrl  ctrl=(CopyCtrl)closure;
    Video  new=CopyHeader(ctrl->video), src=ctrl->video;
    int    frame, channel, i, x, y, X, Y, map[256];

    if (global->batch == NULL)
ctrl->mode=(int)XawToggleGetCurrent(ctrl->radioGroup);
    strcpy(new->name,ctrl->name);
    strcpy(new->files,new->name);
    switch(ctrl->mode) {
case 1:    Dprintf("Direct copy\n");
            new->UVsample[0]=ctrl->UVsample[0];
            new->UVsample[1]=ctrl->UVsample[1];
```

- 109 -

```

        break;
    case 2:    Dprintf("Differences\n");
               break;
    case 3:    Dprintf("LPF zero\n");
               break;
    case 4:    Dprintf("LPF only\n");
               new->trans.type=TRANS_None;

new->size[0]=new->size[0] > > new->trans.wavelet.space[0];

new->size[1]=new->size[1] > > new->trans.wavelet.space[0];
        break;
    case 5:    Dprintf("RGB-YUV\n");
               new->type=new->type==YUV?RGB:YUV;
               new->UVsample[0]=0;
               new->UVsample[1]=0;
               break;
    case 6:    Dprintf("Gamma conversion\n");
               new->gamma=!new->gamma;
               for(i=0;i<256;i++)
map[i]=gamma(i,256,new->gamma?0.5:2.0);
        break;
    }
    if (new->disk==True) SaveHeader(new);
    for(frame=0;frame<new->size[2];frame++) {
        GetFrame(src,frame);
        NewFrame(new,frame);
        switch(ctrl->mode) {
            case 1:
for(channel=0;channel<(new->type==MONO?1:3);channel++) {
                int    size=Size(new,channel,0)*Size(new,channel,1);

```

- 110 -

```

        for(y=0;y < Size(new,channel,1);y++)
            for(x=0;x < Size(new,channel,0);x++)

new->data[channel][frame][x+Size(new,channel,0)*y]=src->data[channel][frame][Shift(
x,src->type==YUV &&
channel!=0?new->UVsample[0]-src->UVsample[0]:0)+Size(src,channel,0)*Shift(y,src-
>type==YUV && channel!=0?new->UVsample[1]-src->UVsample[1]:0)];
    }
    break;

    case 2:
for(channel=0;channel < (new->type==MONO?1:3);channel++) {
    int
size=Size(new,channel,0)*Size(new,channel,1);

    for(i=0;i < size;i++)
new->data[channel][frame][i]=src->data[channel][frame][i]-(frame==0?0:src->data[ch
annel][frame-1][i]);
    }
    break;

    case 3:
for(channel=0;channel < (new->type==MONO?1:3);channel++) {
    int
size=Size(new,channel,0)*Size(new,channel,1);

    for(i=0;i < size;i++) {
        x=i%Size(new,channel,0);
y=i/Size(new,channel,0);

        if
(x%(1 < < new->trans.wavelet.space[new->type==YUV && channel!=0?1:0])==0
&& y%(1 < < new->trans.wavelet.space[new->type==YUV &&
channel!=0?1:0])==0)

```

- 111 -

```

new->data[channel][frame][i]=0;

                                else
new->data[channel][frame][i]=src->data[channel][frame][i];
                                }
                                }
                                break;

        case 4:
for(channel=0;channel<(new->type==MONO?1:3);channel++) {
                                int
size=Size(new,channel,0)*Size(new,channel,1);

                                for(i=0;i<size;i++) {
                                        x=i%Size(new,channel,0);
y=i/Size(new,channel,0);

new->data[channel][frame][i]=src->data[channel][frame][(x+(y<<new->trans.wavele
t.space[0])*Size(new,channel,0))<<new->trans.wavelet.space[0]];
                                }
                                }
                                break;

        case 5:    for(X=0;X<new->size[0];X++)
for(Y=0;Y<new->size[1];Y++) {

                                short  src_triple[3], dst_triple[3];

                                for(channel=0;channel<3;channel++)

src_triple[channel]=src->data[channel][frame][Address(src,channel,X,Y)];

ColCvt(src_triple,dst_triple,new->type==YUV,1<<7+new->precision);

                                for(channel=0;channel<3;channel++)
                                        new->data[channel][frame][Address(new,channel,X,Y)]=dst_triple[channel];
                                }

```

- 112 -

```

        break;

        case 6:
for(channel=0;channel < (new->type == MONO?1:3);channel++) {
                                int
size=Size(new,channel,0)*Size(new,channel,1);

                                for(i=0;i < size;i++)
new->data[channel][frame][i]=map[src->data[channel][frame][i]+128]-128;
                                }
                                break;
        }

        if (frame > 0) FreeFrame(src,frame-1);
        SaveFrame(new,frame);
        FreeFrame(new,frame);
    }
    FreeFrame(src,src->size[2]-1);
    new->next=global->videos;
    global->videos=new;
}

void BatchCopyCtrl(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    CopyCtrl    ctrl=(CopyCtrl)closure;

    if (ctrl->video == NULL)
ctrl->video=FindVideo(ctrl->src_name,global->videos);
    CopyVideoCtrl(w,closure,call_data);
}

```



- 113 -

```
CopyCtrl    InitCopyCtrl(name)
```

```
String name;
```

```
{
    CopyCtrl    ctrl=(CopyCtrl)MALLOC(sizeof(CopyCtrlRec));

    strcpy(ctrl->src_name,name);
    strcpy(ctrl->name,name);
    ctrl->mode=1;
    return(ctrl);
}
```

```
#define      COPY_ICONS      17
```

```
void CopyVideo(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t      closure, call_data;
```

```
{
    Video video=(Video)closure;
    CopyCtrl    ctrl=InitCopyCtrl(video->name);
    NumInput    UVinputs=(NumInput)MALLOC(2*sizeof(NumInputRec));
    Message      msg=NewMessage(ctrl->name,NAME_LEN);
    XtCallbackRec    destroy_call[]={
        {Free,(caddr_t)ctrl},
        {Free,(caddr_t)UVinputs},
        {CloseMessage,(caddr_t)msg},
        {NULL,NULL},
    };
    Widget      shell=ShellWidget("copy_video",w,SW_below,NULL,destroy_call),
```

- 114 -

```

        form=FormatWidget("cpy_form",shell), widgets[COPY_ICONS];
FormItem    items[]={
    {"cpy_cancel","cancel",0,0,FW_icon,NULL},
    {"cpy_confirm","confirm",1,0,FW_icon,NULL},
    {"cpy_title","Copy a video",2,0,FW_label,NULL},
    {"cpy_vid_lab","Video Name:",0,3,FW_label,NULL},
    {"cpy_text",NULL,4,3,FW_text,(String)msg},

    {"cpy_copy","copy",0,5,FW_toggle,NULL},
    {"cpy_diff","diff",6,5,FW_toggle,(String)6},
    {"cpy_lpf_zero","lpf_zero",7,5,FW_toggle,(String)7},
    {"cpy_lpf_only","lpf_only",8,5,FW_toggle,(String)8},
    {"cpy_color","color_space",9,5,FW_toggle,(String)9},

    {"cpy_gamma","gamma",10,5,FW_toggle,(String)10},
    {"cpy_UV0_int",NULL,0,6,FW_integer,(String)&UVinputs[0]},
    {"cpy_UV0_down",NULL,12,6,FW_down,(String)&UVinputs[0]},
    {"cpy_UV0_up",NULL,13,6,FW_up,(String)&UVinputs[0]},
    {"cpy_UV1_int",NULL,0,14,FW_integer,(String)&UVinputs[1]},

    {"cpy_UV1_down",NULL,12,14,FW_down,(String)&UVinputs[1]},
    {"cpy_UV1_up",NULL,16,14,FW_up,(String)&UVinputs[1]},
};

XtCallbackRec    callbacks[]={
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {CopyVideoCtrl,(caddr_t)ctrl},
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {NULL,NULL}, {NULL,NULL}, {NULL,NULL}, {NULL,NULL},
{NULL,NULL}, {NULL,NULL},
    {NumIncDec,(caddr_t)&UVinputs[0]}, {NULL,NULL},

```

- 115 -

```
        {NumIncDec,(caddr_t)&UVinputs[0]}, {NULL,NULL},
        {NumIncDec,(caddr_t)&UVinputs[1]}, {NULL,NULL},
        {NumIncDec,(caddr_t)&UVinputs[1]}, {NULL,NULL},
    };

    Dprintf("CopyVideo\n");

    msg->rows=1; msg->cols=NAME_LEN;
    ctrl->video=video;
    UVinputs[0].format="UV sub-sample X: %d";
    UVinputs[0].min=0;
    UVinputs[0].max=2;
    UVinputs[0].value = &ctrl->UVsample[0];
    UVinputs[1].format="UV sub-sample Y: %d";
    UVinputs[1].min=0;
    UVinputs[1].max=2;
    UVinputs[1].value = &ctrl->UVsample[1];

    ctrl->UVsample[0]=video->UVsample[0];
    ctrl->UVsample[1]=video->UVsample[1];
    FillForm(form,COPY_ICONS,items,widgets,callbacks);
    ctrl->radioGroup=widgets[5];
    XtSetSensitive(widgets[6],video->size[2]>1);
    XtSetSensitive(widgets[7],video->trans.type!=TRANS_None);
    XtSetSensitive(widgets[8],video->trans.type!=TRANS_None);
    XtSetSensitive(widgets[9],video->type!=MONO);
    XtSetSensitive(widgets[10],video->type!=YUV &&
video->trans.type==TRANS_None);
    XtPopup(shell,XtGrabExclusive);
};
```

- 116 -

## source/Frame.c

```
/*
    Frame callback routines for Destroy
*/

#include    "../include/xwave.h"
#include    <X11/Xmu/SysUtil.h>
#include    <pwd.h>
extern void CvtIndex();
extern Palette FindPalette();
extern void SetSensitive();

typedef    struct {
    Frame frame;
    int    frame_number, frame_zoom, frame_palette, frame_channel;
} ExamCtrlRec, *ExamCtrl;

void    FrameDestroy(w,closure,call_data)

Widget    w;
caddr_t    closure, call_data;

{
    Frame frame=(Frame)closure;
    void    CleanUpPoints(), FrameDelete();

    Dprintf("FrameDestroy\n");
    frame->point->usage--;
    if (frame->msg!=NULL) {
```

- 117 -

```
        frame->msg->shell=NULL;
        CloseMessage(NULL,(caddr_t)frame->msg,NULL);
    }
    if (frame->point->usage==0) CleanUpPoints(&global->points);
    XtPopdown(frame->shell);
    XtDestroyWidget(frame->shell);
    FrameDelete(&global->frames,frame);
}
```

```
void CleanUpPoints(points)
```

```
Point *points;
```

```
{
    Point dummy=*points;

    if (dummy!=NULL) {
        if (dummy->usage<1) {
            *points=dummy->next;
            XtFree(dummy);
            CleanUpPoints(points);
        } else CleanUpPoints(&((*points)->next));
    };
}
```

```
void FrameDelete(frames,frame)
```

```
Frame *frames, frame;
```

```
{
    if (*frames!=NULL) {
        if (*frames==frame) {
```

- 118 -

```

        int    number=frame->frame;

        frame->frame=-1;
        FreeFrame(frame->video,number);
        *frames=frame->next;
        XtFree(frame);
    } else FrameDelete(&(*frames)->next,frame);
}

}

void  ExamineCtrl(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    ExamCtrl  ctrl=(ExamCtrl)closure;
    Arg  args[1];

    if (ctrl->frame->frame!=ctrl->frame_number-ctrl->frame->video->start) {
        int    old_frame=ctrl->frame->frame;

        ctrl->frame->frame=ctrl->frame_number-ctrl->frame->video->start;
        FreeFrame(ctrl->frame->video,old_frame);
        GetFrame(ctrl->frame->video,ctrl->frame->frame);
    }

    ctrl->frame->zoom=ctrl->frame_zoom;
    ctrl->frame->palette=ctrl->frame_palette;
    ctrl->frame->channel=ctrl->frame_channel;
    XtSetArg(args[0],XtNbitmap,UpdateImage(ctrl->frame));
    XtSetValues(ctrl->frame->image_widget,args,ONE);

```

- 119 -

```

XtSetArg(args[0],XtNcolormap,ChannelCmap(ctrl->frame->channel,ctrl->frame->vide
o->type,ctrl->frame->video->gamma));
    XtSetValues(ctrl->frame->shell,args,ONE);
    if (ctrl->frame->msg!=NULL) UpdateInfo(ctrl->frame);
}

```

```

#define      EXAM_ICONS      13

```

```

void  Examine(w,closure,call_data)

```

```

Widget      w;

```

```

caddr_t      closure, call_data;

```

```

{

```

```

    ExamCtrl  ctrl=(ExamCtrl)MALLOC(sizeof(ExamCtrlRec));

```

```

    NumInput  num_inputs=(NumInput)MALLOC(2*sizeof(NumInputRec));

```

```

    XtCallbackRec destroy_call[]={

```

```

        {Free,(caddr_t)ctrl},

```

```

        {Free,(caddr_t)num_inputs},

```

```

        {NULL,NULL},

```

```

    }, pal_call[2*global->no_pals];

```

```

    Widget    shell=ShellWidget("examine",w,SW_below,NULL,destroy_call),

```

```

        form=FormatWidget("exam_form",shell), widgets[EXAM_ICONS],

```

```

        pal_widgets[global->no_pals], pal_shell;

```

```

    Frame frame=(Frame)closure;

```

```

    FormItem  items[]={

```

```

        {"exam_cancel","cancel",0,0,FW_icon,NULL},

```

```

        {"exam_confirm","confirm",1,0,FW_icon,NULL},

```

```

        {"exam_label","Examine",2,0,FW_label,NULL},

```

```

        {"exam_ch_lab","Channel :",0,3,FW_label,NULL},

```

```

        {"exam_ch_btn",ChannelName[frame->video->type][frame->channel],4,3,FW_button,"

```

- 120 -

```

exam_cng_ch"},
    {"exam_pal_lab", "Palette :", 0, 4, FW_label, NULL},

{"exam_pal_btn", FindPalette(global->palettes, frame->palette)->name, 4, 4, FW_button, "
exam_cng_pal"},
    {"exam_z_int", NULL, 0, 6, FW_integer, (String)&num_inputs[0]},
    {"exam_z_down", NULL, 8, 6, FW_down, (String)&num_inputs[0]},
    {"exam_z_up", NULL, 9, 6, FW_up, (String)&num_inputs[0]},
    {"exam_zoom_int", NULL, 0, 8, FW_integer, (String)&num_inputs[1]},
    {"exam_zoom_down", NULL, 8, 8, FW_down, (String)&num_inputs[1]},
    {"exam_zoom_up", NULL, 12, 8, FW_up, (String)&num_inputs[1]},
};

MenuItem    pal_menu[global->no_pals];
XtCallbackRec    callbacks[]={
    {Destroy, (caddr_t)shell},
    {NULL, NULL},
    {ExamineCtrl, (caddr_t)ctrl},
    {Destroy, (caddr_t)shell},
    {NULL, NULL},
    {NumIncDec, (caddr_t)&num_inputs[0]}, {NULL, NULL},
    {NumIncDec, (caddr_t)&num_inputs[0]}, {NULL, NULL},
    {NumIncDec, (caddr_t)&num_inputs[1]}, {NULL, NULL},
    {NumIncDec, (caddr_t)&num_inputs[1]}, {NULL, NULL},
};

int    i, width=0;

Palette    pal=global->palettes;
XFontStruct    *font;
Arg    args[1];

caddr_t    dummy[global->no_pals], dummy2[global->no_pals]; /*
gcc-mc68020 bug avoidance */

Dprintf("Examine\n");

```



- 121 -

```

ctrl->frame=frame;
ctrl->frame_number=frame->frame+frame->video->start;
ctrl->frame_zoom=frame->zoom;
ctrl->frame_palette=frame->palette;
ctrl->frame_channel=frame->channel;
num_inputs[0].format="Frame: %03d";
num_inputs[0].max=frame->video->start+frame->video->size[2]-1;
num_inputs[0].min=frame->video->start;
num_inputs[0].value=&ctrl->frame_number;
num_inputs[1].format="Zoom: %d";
num_inputs[1].max=4;
num_inputs[1].min=0;
num_inputs[1].value=&ctrl->frame_zoom;

```

```

FillForm(form,EXAM_ICONS,items,widgets,callbacks);

```

```

font=FindFont(widgets[6]);
for(i=0;pal!=NULL;pal=pal->next,i++) {
    pal_menu[i].name=pal->name;
    pal_menu[i].widgetClass=smeBSBObjectClass;
    pal_menu[i].label=pal->name;
    pal_menu[i].hook=NULL;
    pal_call[i*2].callback=SimpleMenu;
    pal_call[i*2].closure=(caddr_t)&ctrl->frame_palette;
    pal_call[i*2+1].callback=NULL;
    pal_call[i*2+1].closure=NULL;
    width=TextWidth(width,pal->name,font);
}
pal_shell=ShellWidget("exam_cng_pal",shell,SW_menu,NULL,NULL);
FillMenu(pal_shell,global->no_pals,pal_menu,pal_widgets,pal_call);
XtSetArg(args[0],XtNwidth,2+width);
XtSetValues(widgets[6],args,ONE);

```

- 122 -

```

    if (frame->video->type == MONO) XtSetSensitive(widgets[4],False);
    else {
        MenuItem    ch_menu[4];
        Widget
ch_shell=ShellWidget("exam_cng_ch",shell,SW_menu,NULL,NULL), ch_widgets[4];
        XtCallbackRec    ch_call[8];

        font=FindFont(widgets[4]);
        width=0;
        for(i=0;i<4;i++) {
            ch_menu[i].name=ChannelName[frame->video->type][i];
            ch_menu[i].widgetClass=smeBSBObjectClass;
            ch_menu[i].label=ChannelName[frame->video->type][i];
            ch_menu[i].hook=(caddr_t)&ctrl->frame_channel;
            ch_call[i*2].callback=SimpleMenu;
            ch_call[i*2].closure=(caddr_t)&ctrl->frame_channel;
            ch_call[i*2+1].callback=NULL;
            ch_call[i*2+1].closure=NULL;

width=TextWidth(width,ChannelName[frame->video->type][i],font);
        }
        FillMenu(ch_shell,4,ch_menu,ch_widgets,ch_call);
        XtSetArg(args[0],XtNwidth,2+width);
        XtSetValues(widgets[4],args,ONE);
    }
    XtPopup(shell,XtGrabExclusive);
}

void  FramePointYN(w,closure,call_data)

Widget      w;
caddr_t      closure, call_data;

```

- 123 -

```

{
    Frame frame=(Frame)closure;
    Arg  args[1];
    Pixmap    pixmap;
    Display    *dpy=XtDisplay(global->toplevel);
    Icon  point_y=FindIcon("point_y"),
          point_n=FindIcon("point_n");

    Dprintf("FramePointYN\n");
    frame->point_switch=!frame->point_switch;
    XtSetSensitive(frame->image_widget,frame->point_switch);
    XtSetArg(args[0],XtNbitmap,(frame->point_switch?point_y:point_n)->pixmap);
    XtSetValues(w,args,ONE);
    XtSetArg(args[0],XtNbitmap,&pixmap);
    XtGetValues(frame->image_widget,args,ONE);
    UpdatePoint(dpy,frame,pixmap);
    XtSetArg(args[0],XtNbitmap,pixmap);
    XtSetValues(frame->image_widget,args,ONE);
    if (frame->msg!=NULL) UpdateInfo(frame);
}

```

```

void  NewPoint(w,closure,call_data)

```

```

Widget      w;
caddr_t     closure, call_data;

```

```

{
    Frame frame=(Frame)closure;
    Video vid=frame->video;
    void  UpdateFrames();
    int   *posn=(int *)call_data,
    channel=frame->channel==3?0:frame->channel;

```

- 124 -

```

    posn[0]=posn[0] > > frame-> zoom; posn[1]=posn[1] > > frame-> zoom;
    if (vid->trans.type==TRANS_Wave) {
        int    octs=vid->trans.wavelet.space[vid->type==YUV &&
channel!=0?1:0], oct;

CvtIndex(posn[0],posn[1],Size(vid,channel,0),Size(vid,channel,1),octs,&posn[0],&posn[1]
,&oct);
    }
    if (vid->type==YUV && channel!=0) {
        posn[0]=posn[0] < < vid-> UVsample[0];
        posn[1]=posn[1] < < vid-> UVsample[1];
    }
    Dprintf("NewPoint %d %d previous %d
%d\n",posn[0],posn[1],frame-> point-> location[0],frame-> point-> location[1]);
    if (posn[0]!=frame-> point-> location[0] ||
posn[1]!=frame-> point-> location[1]) {
        UpdateFrames(global-> frames,frame-> point,False);
        frame-> point-> location[0]=posn[0];
        frame-> point-> location[1]=posn[1];
        UpdateFrames(global-> frames,frame-> point,True);
    } else Dprintf("No movement\n");
}

void  UpdateFrames(frame,point,update)

Frame frame;
Point point;
Boolean    update;

{
    Arg    args[1];

```

- 125 -

```

if (frame!=NULL) {
    if (point==frame->point && frame->point_switch==True) {
        Pixmap      pixmap;
        Display      *dpy=XtDisplay(global->toplevel);

        XtSetArg(args[0],XtNbitmap,&pixmap);
        XtGetValues(frame->image_widget,args,ONE);
        UpdatePoint(dpy,frame,pixmap);
        if (update==True) {
            XtSetArg(args[0],XtNbitmap,pixmap);
            XtSetValues(frame->image_widget,args,ONE);
            if (frame->msg!=NULL) UpdateInfo(frame);
        }
    }
    UpdateFrames(frame->next,point,update);
}
}

```

```

void  CloseInfo(w,closure,call_data)

```

```

Widget      w;
caddr_t      closure, call_data;

```

```

{
    Frame frame=(Frame)closure;

    frame->msg=NULL;
}

```

```

#define      INFO_ICONS      2

```

```

void  FrameInfo(w,closure,call_data)

```

- 126 -

```

Widget      w;
caddr_t     closure, call_data;

{
    Frame frame=(Frame)closure;
    Message   msg=NewMessage(NULL,1000);
    XtCallbackRec   callbacks[]={
        {SetSensitive,(caddr_t)w},
        {CloseInfo,(caddr_t)frame},
        {CloseMessage,(caddr_t)msg},
        {NULL,NULL},
    };
    Dprintf("FrameInfo\n");
    frame->msg=msg;
    UpdateInfo(frame);
    TextSize(msg);
    MessageWindow(w,msg,frame->video->name,True,callbacks);
    XtSetSensitive(w,False);
}

```

```

void  FrameMerge(w,closure,call_data)

```

```

Widget      w;
caddr_t     closure, call_data;

{
    Frame frame=(Frame)closure;
    void  MergePoints();
    Arg   args[1];

    Dprintf("FrameMerge\n");
    MergePoints(global->frames,frame);
}

```

- 127 -

}

```
void MergePoints(frame_search,frame_found)
```

```
Frame frame_search, frame_found;
```

{

```
Arg    args[1];
```

```
if (frame_search!=NULL) {
```

```
    if (NULL==XawToggleGetCurrent(frame_search->point_merge_widget)
```

```
|| frame_search==frame_found)
```

```
    MergePoints(frame_search->next,frame_found);
```

```
    else {
```

```
        Pixmap    pixmap;
```

```
        Display    *dpy=XtDisplay(global->toplevel);
```

```
        XtSetArg(args[0],XtNbitmap,&pixmap);
```

```
        XtGetValues(frame_found->image_widget,args,ONE);
```

```
        if (frame_found->point_switch==True)
```

```
UpdatePoint(dpy,frame_found,pixmap);
```

```
        frame_search->point->usage++;
```

```
        frame_found->point->usage--;
```

```
        if (frame_found->point->usage==0)
```

```
CleanUpPoints(&global->points);
```

```
        frame_found->point=frame_search->point;
```

```
        if (frame_found->point_switch==True) {
```

```
            UpdatePoint(dpy,frame_found,pixmap);
```

```
            XtSetArg(args[0],XtNbitmap,pixmap);
```

```
            XtSetValues(frame_found->image_widget,args,ONE);
```

```
        }
```

```
        if (frame_found->msg!=NULL) UpdateInfo(frame_found);
```

- 128 -

```

        XawToggleUnsetCurrent(frame_search->point_merge_widget);
        XawToggleUnsetCurrent(frame_found->point_merge_widget);
    }
}

}

#define      POST_DIR      "postscript"

void  PostScript(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    Frame frame=(Frame)closure;
    Video video=frame->video;
    FILE *fp, *fopen();
    char  file_name[STRLEN], hostname[STRLEN];
    int   x, y, width=Size(video,frame->channel,0),
height=Size(video,frame->channel,1);
    struct passwd *pswd;
    long  clock;

    Dprintf("PostScript\n");
    sprintf(file_name, "%s%s/%s.ps\0", global->home, POST_DIR, video->name);
    fp=fopen(file_name, "w");
    fprintf(fp, "% %!PS-Adobe-1.0\n");
    pswd = getpwuid (getuid ());
    (void) XmuGetHostname (hostname, sizeof hostname);
    fprintf(fp, "% % % %Creator: %s: %s (%s)\n", hostname, pswd->pw_name,
pswd->pw_gecos);
    fprintf(fp, "% % % %Title: %s\n", video->name);

```



- 129 -

```

fprintf(fp, "%% % % % BoundingBox: 0 0 %d %d\n", width, height);
fprintf(fp, "%% % % % CreationDate: %s", (time (&clock), ctime (&clock)));
fprintf(fp, "%% % % % EndComments\n");
fprintf(fp, "%d %d scale\n", width, height);
fprintf(fp, "%d %d 8 image_print\n", width, height);
GetFrame(video, frame-> frame);
for(y=0; y < height; y++) {
    for(x=0; x < width; x++) {
        int    X, Y, oct, data;

        if (video-> trans.type == TRANS_Wave) {

CvtIndex(x, y, width, height, video-> trans.wavelet.space[0], &X, &Y, &oct);

data=128+Round(video-> data[frame-> channel%3][frame-> frame][Y*video-> size[0] +
X]*(oct==video-> trans.wavelet.space[0]?1:4), video-> precision);
        } else
data=128+Round(video-> data[frame-> channel%3][frame-> frame][y*video-> size[0] +
x], video-> precision);
        fprintf(fp, "%02x", data < 0?0: data > 255?255: data);
    }
    fprintf(fp, "\n");
}
FreeFrame(video, frame-> frame);
fclose(fp);
}

void  Spectrum(w, closure, call_data)

Widget      w;
caddr_t     closure, call_data;

```

- 130 -

```
{
    Frame frame=(Frame)closure;
    Display      *dpy=XtDisplay(global->toplevel);
    XColor       xcolor[2], falsecolor;
    int          i;
    Colormap
cmap=ChannelCmap(frame->channel,frame->video->type,frame->video->gamma);

    Dprintf("Spectrum\n");
    falsecolor.flags=DoRed|DoGreen|DoBlue;
    XSynchronize(dpy,True);
    for(i=0;i<2+global->levels;i++) {
        if (i > 1) XStoreColor(dpy,cmap,&xcolor[i&1]); /* Restore old color */
        if (i < global->levels) {
            xcolor[i&1].pixel=i;
            XQueryColor(dpy,cmap,&xcolor[i&1]);
            falsecolor.pixel=i;
            falsecolor.red=xcolor[i&1].red+32512;
            falsecolor.green=xcolor[i&1].green+32512;
            falsecolor.blue=xcolor[i&1].blue+32512;
            XStoreColor(dpy,cmap,&>falsecolor);
        }
    }
    XSynchronize(dpy,False);
}
```

- 131 -

## source/icon3.c

```
/*
    Create Icons/Menus and set Callbacks
*/

#include    "../include/xwave.h"

/*    Function Name:    FindIcon
 *    Description:    Finds IconRec entry from name in global icon array
 *    Arguments:    icon_name - name of icon bitmap
 *    Returns:    pointer to IconRec with the same name as icon_name
 */

Icon FindIcon(icon_name)

String icon_name;

{
    int    i;
    Icon    icon=NULL;

    for (i=0;i<global->no_icons;i++)
        if (!strcmp(global->icons[i].name,icon_name)) icon=&global->icons[i];
    return(icon);
}

void FillForm(parent,number,items,widgets,callbacks)

int    number;
```

- 132 -

```

FormItem    items[];
Widget      parent, widgets[];
XtCallbackRec  callbacks[];

{
    Arg    args[10];
    int    i, call_i=0;

    for(i=0;i<number;i++) {
        int    argc=0, *view=(int *)items[i].hook;
        char    text[STRLEN];
        float    top;
        NumInput    num=(NumInput)items[i].hook;
        FloatInput    flt=(FloatInput)items[i].hook;
        Message    msg=(Message)items[i].hook;
        WidgetClass
class[15]={labelWidgetClass,commandWidgetClass,commandWidgetClass,asciiTextWidge
tClass,

menuButtonWidgetClass,menuButtonWidgetClass,viewportWidgetClass,toggleWidgetClass

commandWidgetClass,commandWidgetClass,commandWidgetClass,labelWidgetClass,
        scrollbarWidgetClass,labelWidgetClass,formWidgetClass};
        Boolean
call[15]={False,True,True,False,False,False,False,True,True,True,True,False,False,Fals
e,False};

        if (items[i].fromHoriz!=0) {
            XtSetArg(args[argc],XtNfromHoriz,widgets[items[i].fromHoriz-1]);
            argc++;
        }
    }
}

```

- 133 -

```

    if (items[i].fromVert!=0) {
        XtSetArg(args[argc],XtNfromVert,widgets[items[i].fromVert-1]);
argc++;
    }
    switch(items[i].type) { /* Initialise contents */
case FW_yn:
        items[i].contents=*(Boolean *)items[i].hook?"confirm":"cancel";
        break;
case FW_up:
        items[i].contents="up";
        break;
case FW_down:
        items[i].contents="down";
        break;
case FW_integer:
        sprintf(text,num->format,*num->value);
        items[i].contents=text;
        break;
case FW_float:
        sprintf(text,flt->format,*flt->value);
        items[i].contents=text;
        break;
    }
    switch(items[i].type) { /* Set contents */
case FW_label: case FW_command: case FW_button: case FW_integer:
case FW_float:
        XtSetArg(args[argc],XtNlabel,items[i].contents); argc++;
        break;
case FW_down: case FW_up: case FW_yn: case FW_toggle: case
FW_icon: case FW_icon_button: {
        Icon    icon=FindIcon(items[i].contents);

```

- 134 -

```

    if (icon == NULL) {
        XtSetArg(args[argc], XtNlabel, items[i].contents); argc++;
    } else {
        XtSetArg(args[argc], XtNbitmap, icon->pixmap); argc++;
        XtSetArg(args[argc], XtNheight, icon->height+2); argc++;
        XtSetArg(args[argc], XtNwidth, icon->width+2); argc++;
    }
    } break;
}

switch(items[i].type) { /* Individual set-ups */
case FW_text:
    XtSetArg(args[argc], XtNstring, msg->info.ptr); argc++;
    XtSetArg(args[argc], XtNeditType, msg->edit); argc++;
    XtSetArg(args[argc], XtNuseStringInPlace, True); argc++;
    XtSetArg(args[argc], XtNlength, msg->size); argc++;
    break;

case FW_button: case FW_icon_button:
    XtSetArg(args[argc], XtNmenuName, (String)items[i].hook);
    argc++;

    break;

case FW_toggle:
    if ((int)items[i].hook == 0) {
        XtSetArg(args[argc], XtNradioData, 1); argc++;
    } else {
        caddr_t radioData;
        Arg radioargs[1];
        Widget radioGroup = widgets[(int)items[i].hook-1];

        XtSetArg(radioargs[0], XtNradioData, &radioData);
        XtGetValues(radioGroup, radioargs, ONE);

        XtSetArg(args[argc], XtNradioData, (caddr_t)((int)radioData+1)); argc++;
    }
}

```

- 135 -

```

        XtSetArg(args[argc],XtNradioGroup,radioGroup); argc++;
    }
    break;
case FW_scroll:
    top=(float)(*flt->value-flt->min)/(flt->max-flt->min);
    XtSetArg(args[argc],XtNtopOfThumb,&top); argc++;
    XtSetArg(args[argc],XtNjumpProc,&callbacks[call_i]); argc++;
    while(callbacks[call_i].callback!=NULL) call_i++;
    call_i++;
    break;
case FW_view:
    if (view!=NULL) {
        XtSetArg(args[argc],XtNwidth,view[0]); argc++;
        XtSetArg(args[argc],XtNheight,view[1]); argc++;
    }
    break;
}

widgets[i]=XtCreateManagedWidget(items[i].name,class[(int)items[i].type],parent,args,argc);

switch(items[i].type) { /* Post processing */
case FW_toggle:
    if (items[i].hook==NULL) { /* Avoids Xaw bug */
        XtSetArg(args[0],XtNradioGroup,widgets[i]);
        XtSetValues(widgets[i],args,ONE);
    }
    break;
case FW_text: {
    XFontStruct *font;
    Arg text_args[1];

    msg->widget=widgets[i];

```

- 136 -

```

XawTextDisplayCaret(msg->widget,msg->edit!=XawtextRead);
XtSetArg(text_args[0],XtNfont,&font);
XtGetValues(widgets[i],text_args,ONE);
argc=0;
if (msg->edit==XawtextRead && msg->info.ptr[0]!='\0')
XtSetArg(args[argc],XtNwidth,4+TextWidth(0,msg->info.ptr,font));
else
XtSetArg(args[argc],XtNwidth,4+msg->cols*(font->max_bounds.width+font->min_bo
unds.width)/2);

argc++;

XtSetArg(args[argc],XtNheight,1+msg->rows*(font->max_bounds.ascent+font->max_
bounds.descent)); argc++;

XtSetValues(widgets[i],args,argc);
} break;
case FW_button:

XtOverrideTranslations(widgets[i],XtParseTranslationTable("< BtnDown>: reset()
NameButton() PopupMenu()"));
break;
case FW_down:
if (*num->value==num->min) XtSetSensitive(widgets[i],False);
num->widgets[0]=widgets[i];
break;
case FW_up:
if (*num->value==num->max) XtSetSensitive(widgets[i],False);
num->widgets[1]=widgets[i];
break;
case FW_integer:
num->widgets[2]=widgets[i];
break;
case FW_scroll:

```



- 137 -

```

        flt->widgets[1]=widgets[i];
        XawScrollbarSetThumb(widgets[i],top,0.05);
        break;
    case FW_float:
        flt->widgets[0]=widgets[i];
        break;
    }
    if (call[(int)items[i].type]) { /* Add Callbacks */
        if (callbacks[call_i].callback!=NULL)
            XtAddCallbacks(widgets[i],XtNcallback,&callbacks[call_i]);
        while(callbacks[call_i].callback!=NULL) call_i++;
        call_i++;
    }
}
}

```

Widget       ShellWidget(name,parent,type,cmap,callbacks)

String name;

Widget       parent;

ShellWidgetType   type;

Colormap       cmap;

XtCallbackRec     callbacks[];

{

Widget       shell;

Arg   args[3];

Position     x, y;

Dimension    height=-2;

int   argc=0;

WidgetClass

class[]={transientShellWidgetClass,transientShellWidgetClass,topLevelShellWidgetClass,p

- 138 -

ullRightMenuWidgetClass};

```

    if (type == SW_below || type == SW_over) {
        XtTranslateCoords(parent, 0, 0, &x, &y);
        if (type == SW_below) {
            XtSetArg(args[0], XtNheight, &height);
            XtGetValues(parent, args, ONE);
        }
        XtSetArg(args[argc], XtNx, x); argc++;
        XtSetArg(args[argc], XtNy, y + height + 2); argc++;
    }
    if (cmap != NULL) {
        XtSetArg(args[argc], XtNcolormap, cmap); argc++;
    }
    shell = XtCreatePopupShell(name, class[type], parent, args, argc);
    if (callbacks != NULL) XtAddCallbacks(shell, XtNdestroyCallback, callbacks);
    return(shell);
}

```

Widget      FormatWidget(name, parent)

String name;

Widget      parent;

```

{
    return(XtCreateManagedWidget(name, formWidgetClass, parent, NULL, ZERO));
}

```

void    FillMenu(parent, number, items, widgets, callbacks)

int      number;

MenuItem    items[];

- 139 -

```

Widget      parent, widgets[];
XtCallbackRec  callbacks[];

{
    Arg      args[4];
    int      i, call_i=0;
    Icon      icon=FindIcon("right");

    for(i=0;i<number;i++) {
        int      argc=0;

        XtSetArg(args[argc],XtNlabel,items[i].label); argc++;
        if (items[i].widgetClass == smeBSBprObjectClass) {
            XtSetArg(args[argc],XtNmenuName,items[i].hook); argc++;
            XtSetArg(args[argc],XtNrightMargin,4+icon->width); argc++;
            XtSetArg(args[argc],XtNrightBitmap,icon->pixmap); argc++;
        }

        widgets[i]=XtCreateManagedWidget(items[i].name,items[i].widgetClass,parent,args,argc)
        ;

        if (items[i].widgetClass == smeBSBObjectClass) { /* Add Callbacks */
            XtAddCallbacks(widgets[i],XtNcallback,&callbacks[call_i]);
            while(callbacks[call_i].callback!=NULL) call_i++;
            call_i++;
        }
    }
}

void SimpleMenu(w,closure,call_data)

Widget      w;
caddr_t      closure, call_data;

```

- 140 -

```

{
    int      *hook=(int *)closure, no_child, child, argc=0;
    Widget      menu=XtParent(w), button;
    WidgetList  children;
    char      *label;
    Arg      args[3];

    XtSetArg(args[argc],XtNlabel,&label); argc++;
    XtGetValues(w,args,argc); argc=0;
    XtSetArg(args[argc],XtNchildren,&children); argc++;
    XtSetArg(args[argc],XtNnumChildren,&no_child); argc++;
    XtSetArg(args[argc],XtNbutton,&button); argc++;
    XtGetValues(menu,args,argc); argc=0;
    for(child=0;children[child]!=w && child<no_child;) child++;
    if (w!=children[child]) Eprintf("SimpleMenu: menu error\n");
    *hook=child;
    XtSetArg(args[argc],XtNlabel,label); argc++;
    XtSetValues(button,args,argc);
}

```

```

void  NumIncDec(w,closure,call_data)

```

```

Widget      w;
caddr_t      closure, call_data;

```

```

{
    NumInput  data=(NumInput)closure;
    Arg      args[1];
    char      text[STRLEN];

    *data->value+=(w==data->widgets[0])?-1:1;
    sprintf(text,data->format,*data->value);
}

```

- 141 -

```

    if (data->min == *data->value) XtSetSensitive(data->widgets[0],False);
    else XtSetSensitive(data->widgets[0],True);
    if (data->max == *data->value) XtSetSensitive(data->widgets[1],False);
    else XtSetSensitive(data->widgets[1],True);
    XtSetArg(args[0],XtNlabel,text);
    XtSetValues(data->widgets[2],args,ONE);
}

```

```

void FloatIncDec(w,closure,call_data)

```

```

Widget      w;
caddr_t     closure, call_data;

{
    FloatInput data=(FloatInput)closure;
    Arg  args[1];
    char text[STRLEN];
    float percent=*(float *)call_data;

    *data->value=data->min+(double)percent*(data->max-data->min);
    sprintf(text,data->format,*data->value);
    XtSetArg(args[0],XtNlabel,text);
    XtSetValues(data->widgets[0],args,ONE);
}

```

```

/*  Function Name:    ChangeYN
*
*  Description:      Toggle YN widget state
*
*  Arguments:       w - toggling widget
*
*                   closure - pointer to boolean state
*                   call_data - not used
*
*  Returns:         none.
*/

```

- 142 -

```
void ChangeYN(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
    Boolean   *bool=(Boolean *)closure;
    Icon      icon=FindIcon((*bool != True)?"confirm":"cancel");
    Arg       args[4];
    int       argc=0;

    *bool = ! *bool;
    XtSetArg(args[argc],XtNbitmap,icon->pixmap); argc++;
    XtSetArg(args[argc],XtNheight,icon->height+2); argc++;
    XtSetArg(args[argc],XtNwidth,icon->width+2); argc++;
    XtSetValues(w,args,argc);
}
```

```
int TextWidth(max,text,font)
```

```
int      max;
```

```
String text;
```

```
XFontStruct *font;
```

```
{
    int      i=0, j;

    while(text[i]!='\0') {
        int      width;

        for(j=0;text[i+j]!='\0' && text[i+j]!='\n';) j++;
        width=XTextWidth(font,&text[i],j);
    }
}
```

- 143 -

max = max > width?max:width;

/\*\*\*\*\*

Copyright 1987, 1988 by Digital Equipment Corporation, Maynard, Massachusetts,  
and the Massachusetts Institute of Technology, Cambridge, Massachusetts.

All Rights Reserved

Permission to use, copy, modify, and distribute this software and its  
documentation for any purpose and without fee is hereby granted,  
provided that the above copyright notice appear in all copies and that  
both that copyright notice and this permission notice appear in  
supporting documentation, and that the names of Digital or MIT not be  
used in advertising or publicity pertaining to distribution of the  
software without specific, written prior permission.

DIGITAL DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS SOFTWARE,  
INCLUDING

ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS, IN NO  
EVENT SHALL

DIGITAL BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL  
DAMAGES OR

ANY DAMAGES WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR  
PROFITS,

WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR OTHER  
TORTIOUS ACTION,

ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF  
THIS  
SOFTWARE.

\*\*\*\*\*/

- 144 -

```

/*
 * Image.c - Image widget
 *
 */

#define XtStrlen(s)      ((s) ? strlen(s) : 0)

#include <stdio.h>
#include <ctype.h>
#include <X11/IntrinsicP.h>
#include <X11/StringDefs.h>
#include <X11/Xaw/XawInit.h>
#include "../include/ImageP.h"

#define streq(a,b) (strcmp( (a), (b) ) == 0)

/*****
 *
 * Full class record constant
 *
 *****/

/* Private Data */

static char  defaultTranslations[] =
    "<Btn1Down>: notify()\n\
    <Btn1Motion>: notify()\n\
    <Btn1Up>: notify()";

#define offset(field) XtOffset(ImageWidget, field)

static XtResource resources[] = {
    {XtNbitmap, XtCPixmap, XtRBitmap, sizeof(Pixmap),

```



- 145 -

```

        offset(image.pixmap), XtRImmediate, (caddr_t)None},
        {XtNcallback, XtCCallback, XtRCallback, sizeof(XtPointer),
        offset(image.callbacks), XtRCallback, (XtPointer)NULL},
    };

```

```

static void Initialize();
static void Resize();
static void Redisplay();
static Boolean SetValues();
static void ClassInitialize();
static void Destroy();
static XtGeometryResult QueryGeometry();

```

```

static void Notify(), GetBitmapInfo();

```

```

static XtActionsRec      actionsList[]={
    {"notify",    Notify},
};

```

```

ImageClassRec imageClassRec = {
    {
/* core_class fields */
#define superclass      (&simpleClassRec)
/* superclass          */ (WidgetClass) superclass,
/* class_name           */ "Image",
/* widget_size          */ sizeof(ImageRec),
/* class_initialize     */ ClassInitialize,
/* class_part_initialize */ NULL,
/* class_inited         */ FALSE,
/* initialize           */ Initialize,
/* initialize_hook      */ NULL,
/* realize              */ XtInheritRealize,

```

- 146 -

```

/* actions          */ actionsList,
/* num_actions      */ XtNumber(actionsList),
/* resources        */ resources,
/* num_resources    */ XtNumber(resources),
/* xrm_class        */ NULLQUARK,
/* compress_motion   */ TRUE,
/* compress_exposure */ TRUE,
/* compress_enterleave */ TRUE,
/* visible_interest */ FALSE,
/* destroy          */ Destroy,
/* resize           */ Resize,
/* expose           */ Redisplay,
/* set_values       */ SetValues,
/* set_values_hook   */ NULL,
/* set_values_almost */ XtInheritSetValuesAlmost,
/* get_values_hook   */ NULL,
/* accept_focus      */ NULL,
/* version           */ XtVersion,
/* callback_private  */ NULL,
/* tm_table          */ defaultTranslations,
/* query_geometry     */ QueryGeometry,
/* display_accelerator */ XtInheritDisplayAccelerator,
/* extension         */ NULL
},
/* Simple class fields initialization */
{
/* change_sensitive */ XtInheritChangeSensitive
}
};

WidgetClass imageWidgetClass = (WidgetClass)&imageClassRec;
/*****
*
```

- 147 -

\* Private Procedures

\*

\*\*\*\*\*/

static void ClassInitialize()

{

extern void XmuCvtStringToBitmap();

static XtConvertArgRec screenConvertArg[] = {

{XtWidgetBaseOffset, (caddr\_t) XtOffset(Widget, core.screen),  
sizeof(Screen \*)}

};

XawInitializeWidgetSet();

XtAddConverter("String", "Bitmap", XmuCvtStringToBitmap,  
screenConvertArg, XtNumber(screenConvertArg));

} /\* ClassInitialize \*/

/\* ARGSUSED \*/

static void Initialize(request,new)

Widget request, new;

{

ImageWidget iw = (ImageWidget) new;

Dprintf("ImageInitialize\n");

if (iw->image.pixmap == NULL)

XtErrorMsg("NoBitmap", "asciiSourceCreate", "XawError",  
"Image widget has no bitmap.", NULL, 0);

GetBitmapInfo(new);

if (iw->image.map\_width <= 0 || iw->image.map\_height <= 0)

XtErrorMsg("NoDimension", "asciiSourceCreate", "XawError",  
"Image widget illegal map dimension.", NULL, 0);

- 148 -

```
if (iw->core.width == 0) iw->core.width=iw->image.map_width;
    if (iw->core.height == 0) iw->core.height=iw->image.map_height;

(*XtClass(new)->core_class.resize) ((Widget)iw);

} /* Initialize */

/*
 * Repaint the widget window
 */

/* ARGSUSED */
static void Redisplay(w, event, region)
    Widget w;
    XEvent *event;
    Region region;
{
    ImageWidget iw = (ImageWidget) w;

    Dprintf("ImageRedisplay\n");
    if (region != NULL &&
        XRectInRegion(region, 0, 0,
            iw->image.map_width, iw->image.map_height)
        == RectangleOut)
        return;

    XCopyArea(
        XtDisplay(w), iw->image.pixmap, XtWindow(w),
        DefaultGC(XtDisplay(w),XDefaultScreen(XtDisplay(w))),
        0, 0, iw->image.map_width, iw->image.map_height, 0, 0);
}
```

- 149 -

```
static void Resize(w)
    Widget w;
{
    ImageWidget iw = (ImageWidget)w;
    Dprintf("ImageResize\n");
}

/*
 * Set specified arguments into widget
 */

static Boolean SetValues(current, request, new, args, num_args)
    Widget current, request, new;
    ArgList args;
    Cardinal *num_args;
{
    ImageWidget curiw = (ImageWidget) current;
    ImageWidget reqiw = (ImageWidget) request;
    ImageWidget newiw = (ImageWidget) new;
    Boolean redisplay = False;

    /* recalculate the window size if something has changed. */

    if (curiw->image.pixmap != newiw->image.pixmap)
XFreePixmap(XtDisplay(curiw),curiw->image.pixmap);
    GetBitmapInfo(newiw);
    newiw->core.width=newiw->image.map_width;
    newiw->core.height=newiw->image.map_height;
    redisplay=True;

    return redisplay || XtIsSensitive(current) != XtIsSensitive(new);
}
```

- 150 -

```
static void Destroy(w)
    Widget w;
{
    ImageWidget iw = (ImageWidget)w;

    Dprintf("ImageDestroy\n");
}

static XtGeometryResult QueryGeometry(w, intended, preferred)
    Widget w;
    XtWidgetGeometry *intended, *preferred;
{
    register ImageWidget iw = (ImageWidget)w;

    preferred->request_mode = CWWidth | CWHeight;
    preferred->width = iw->image.map_width;
    preferred->height = iw->image.map_height;
    if ( ((intended->request_mode & (CWWidth | CWHeight))
        == (CWWidth | CWHeight)) &&
        intended->width == preferred->width &&
        intended->height == preferred->height)
        return XtGeometryYes;
    else if (preferred->width == w->core.width &&
        preferred->height == w->core.height)
        return XtGeometryNo;
    else
        return XtGeometryAlmost;
}

static void GetBitmapInfo(w)
```

- 151 -

```

Widget      w;

{
    ImageWidget iw=(ImageWidget)w;
    unsigned int  depth, bw;
    Window      root;
    int         x, y;
    unsigned int  width, height;
    char        buf[BUFSIZ];

    if (iw->image.pixmap != None) {
        if
(!XGetGeometry(XtDisplayOfObject(w),iw->image.pixmap,&root,&x,&y,&width,&height,&bw,&depth)) {
            sprintf(buf, "ImageWidget: %s %s \"%s\".", "Could not",
                "get Bitmap geometry information for Image ",
                XtName(w));
            XtAppError(XtWidgetToApplicationContext(w), buf);
        }
        iw->image.map_width=(Dimension)width;
        iw->image.map_height=(Dimension)height;
    }
}

/*
 *   Action Procedures
 */

static void  Notify(w,event,params,num_params)

Widget      w;
XEvent      *event;

```

- 152 -

```
String *params;
Cardinal      *num_params;

{
    ImageWidget iw=(ImageWidget)w;
    XButtonEvent      *buttonevent=&event->xbutton;
    int      posn[2]={buttonevent->x,buttonevent->y};

    if (iw->image.map_width<=posn[0] || posn[0]<0 ||
        iw->image.map_height<=posn[1] || posn[1]<0) Dprintf("No
ImageNotify\n");
    else {
        Dprintf("ImageNotify\n");
        XtCallCallbackList(w,iw->image.callbacks,posn);
    }
}
```



- 153 -

source/ImpKlicsTestSA.c

```
/*
    Test harness for KlicsFrameSA() in Klics.SA
*/

#include    "xwave.h"
#include    "KlicsSA.h"

void  ImpKlicsTestSA(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    int      sizeY=SA_WIDTH*SA_HEIGHT,
             sizeUV=SA_WIDTH*SA_HEIGHT/4;
    short    *dst[3]={
        (short *)MALLOC(sizeof(short)*sizeY),
        (short *)MALLOC(sizeof(short)*sizeUV),
        (short *)MALLOC(sizeof(short)*sizeUV),
    }, *src[3];
    Video    video=(Video)MALLOC(sizeof(VideoRec));
    int      i, z;
    char      file_name[STRLEN];
    Bits      bfp;
    Boolean   stillvid;

    strcpy(video->name,((XawListReturnStruct *)call_data)->string);
```

- 154 -

```

sprintf(file_name,"%s%s/%s%s\0",global->home,KLICS_SA_DIR,video->name,KLICS
_SA_EXT);

bfp=bopen(file_name,"r");
bread(&stillvid,1,bfp);
bread(&video->size[2],sizeof(int)*8,bfp);
video->data[0]=(short **)MALLOC(sizeof(short *)*video->size[2]);
video->data[1]=(short **)MALLOC(sizeof(short *)*video->size[2]);
video->data[2]=(short **)MALLOC(sizeof(short *)*video->size[2]);
video->disk=False;
video->type=YUV;
video->size[0]=SA_WIDTH;
video->size[1]=SA_HEIGHT;
video->UVsample[0]=1;
video->UVsample[1]=1;
video->trans.type=TRANS_None;
for(z=0;z<video->size[2];z++) {
    NewFrame(video,z);
    src[0]=video->data[0][z];
    src[1]=video->data[1][z];
    src[2]=video->data[2][z];
    KlicsFrameSA(z==0 || stillvid?STILL:SEND,src,dst,bfp);
    SaveFrame(video,z);
    FreeFrame(video,z);
}
bclose(bfp);
video->next=global->videos;
global->videos=video;
XtFree(dst[0]);
XtFree(dst[1]);
XtFree(dst[2]);
}

```

- 155 -

source/ImportKlics.c

```
/*
 *   Importing raw Klics binary files
 */

#include    "xwave.h"
#include    "Klics.h"

extern Bits  bopen();
extern void  bclose(), bread(), bwrite(), bflush();

extern void  SkipFrame();
extern int   HuffRead();
extern Boolean  BlockZero();
extern void  ZeroCoeffs();
extern int   ReadInt();
extern int   Decide();
extern double  DecideDouble();

Boolean  BoolToken(bfp)

Bits  bfp;

{
    Boolean  token;

    bread(&token,1,bfp);
    return(token);
}
```

- 156 -

```
void HuffBlock(block,bfp)
```

```
Block block;
```

```
Bits bfp;
```

```
{
```

```
int X, Y;
```

```
for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
```

```
block[X][Y]=HuffRead(bfp);
```

```
}
```

```
void PrevBlock(old,addr,x,y,z,oct,sub,channel,ctrl)
```

```
Block old, addr;
```

```
int x, y, z, oct, sub, channel;
```

```
CompCtrl ctrl;
```

```
{
```

```
int X, Y;
```

```
for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
```

```
addr[X][Y]=Access((x<<1)+X,(y<<1)+Y,oct,sub,Size(ctrl->dst,channel,0));
```

```
old[X][Y]=ctrl->dst->data[channel][z][addr[X][Y]];
```

```
}
```

```
}
```

```
void DeltaBlock(new,old,delta,step)
```

```
Block new, old, delta;
```

```
int step;
```

- 157 -

```
{  
    int    X, Y;  
  
    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)  
  
    new[X][Y]=old[X][Y]+delta[X][Y]*step+(delta[X][Y]!=0?negif(delta[X][Y]<0,(step-1)  
>>1):0);  
}
```

```
void  UpdateBlock(new,addr,z,channel,ctrl)
```

```
int    z, channel;  
Block new, addr;  
CompCtrl  ctrl;
```

```
{  
    int    X, Y;  
  
    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)  
        ctrl->dst->data[channel][z][addr[X][Y]]=(short)new[X][Y];  
}
```

```
void  ReadKlicsHeader(ctrl)
```

```
CompCtrl  ctrl;
```

```
{  
    KlicsHeaderRec  head;  
    int    i;  
    Video  dst=ctrl->dst;  
  
    fread(&head,sizeof(KlicsHeaderRec),1,ctrl->bfp->fp);
```

- 158 -

```

ctrl->stillvid=head.stillvid;
ctrl->auto_q=head.auto_q;
ctrl->buf_switch=head.buf_switch;
ctrl->quant_const=head.quant_const;
ctrl->thresh_const=head.thresh_const;
ctrl->cmp_const=head.cmp_const;
ctrl->fps=head.fps;
for(i=0;i<5;i++) ctrl->base_factors[i]=head.base_factors[i];
ctrl->diag_factor=head.diag_factor;
ctrl->chrome_factor=head.chrome_factor;
ctrl->decide=head.decide;
strcpy(dst->name,ctrl->bin_name);
dst->type=head.type;
dst->disk=head.disk;
dst->gamma=head.gamma;
dst->rate=head.rate;
dst->start=head.start;
for(i=0;i<3;i++) dst->size[i]=head.size[i];
for(i=0;i<2;i++) dst->UVsample[i]=head.UVsample[i];
dst->trans=head.trans;
dst->precision=head.precision;
for(i=0;i<(dst->type==MONO?1:3);i++)
    dst->data[i]=(short **)MALLOC(dst->size[2]*sizeof(short *));
}

```

```
void WriteKlicsHeader(ctrl)
```

```
CompCtrl ctrl;
```

```
{
```

```
    KlicsHeaderRec head;
```

```
    int i;
```

- 159 -

```

    head.stillvid=ctrl->stillvid;
    head.auto_q=ctrl->auto_q;
    head.buf_switch=ctrl->buf_switch;
    head.quant_const=ctrl->quant_const;
    head.thresh_const=ctrl->thresh_const;
    head.cmp_const=ctrl->cmp_const;
    head.fps=ctrl->fps;
    for(i=0;i<5;i++) head.base_factors[i]=ctrl->base_factors[i];
    head.diag_factor=ctrl->diag_factor;
    head.chrome_factor=ctrl->chrome_factor;
    head.decide=ctrl->decide;
    head.type=ctrl->dst->type;
    head.disk=ctrl->dst->disk;
    head.gamma=ctrl->dst->gamma;
    head.rate=ctrl->dst->rate;
    head.start=ctrl->dst->start;
    for(i=0;i<3;i++) head.size[i]=ctrl->dst->size[i];
    for(i=0;i<2;i++) head.UVsample[i]=ctrl->dst->UVsample[i];
    head.trans=ctrl->dst->trans;
    head.precision=ctrl->dst->precision;
    fwrite(&head,sizeof(KlicsHeaderRec),1,ctrl->bfp->fp);
}

```

```

void KlicsTree(mode,x,y,z,oct,sub,channel,ctrl)

```

```

int mode, x, y, z, oct, sub, channel;

```

```

CompCtrl ctrl;

```

```

{

```

```

    Block addr, old, new, delta, zero_block={{0,0},{0,0}};

```

```

    double norms[3]={ctrl->quant_const,ctrl->thresh_const,ctrl->cmp_const};

```

```

    int step;

```

- 160 -

```

PrevBlock(old,addr,x,y,z,oct,sub,channel,ctrl);
if (mode!=VOID) {
    CalcNormals(ctrl,oct,sub,channel,norms);
    step=norms[0] < 1.0?1:(int)norms[0];
    if (mode==STILL || BlockZero(old)) {
        if (BoolToken(ctrl->bfp)) { /* NON_ZERO_STILL */
            Dprintf("NON_ZERO_STILL\n");
            HuffBlock(delta,ctrl->bfp);
            DeltaBlock(new,old,delta,step);
            UpdateBlock(new,addr,z,channel,ctrl);
        } else {
            Dprintf("ZERO_STILL\n");
            mode=STOP; /* ZERO_STILL */
        }
    } else {
        if (!BoolToken(ctrl->bfp)) { /* BLOCK_SAME */
            Dprintf("BLOCK_SAME\n");
            mode=STOP;
        } else {
            if (!BoolToken(ctrl->bfp)) { /* ZERO_VID */
                Dprintf("ZERO_VID\n");
                ZeroCoeffs(ctrl->dst->data[channel][z],addr);
                mode=VOID;
            } else { /*
BLOCK_CHANGE */
                Dprintf("BLOCK_CHANGE\n");
                HuffBlock(delta,ctrl->bfp);
                DeltaBlock(new,old,delta,step);
                UpdateBlock(new,addr,z,channel,ctrl);
            }
        }
    }
}

```



- 161 -

```

    } else {
        if (BlockZero(old)) mode=STOP;
        else {
            ZeroCoeffs(ctrl->dst->data[channel][z],addr);
            mode=VOID;
        }
    }
    if (oct>0 && mode!=STOP) {
        Boolean    decend=mode==VOID?True:BoolToken(ctrl->bfp);
        int    X, Y;

        Dprintf("x= %d, y= %d, oct= %d sub= %d mode
%d\n",x,y,oct,sub,mode);
        if (decend) {
            if (mode!=VOID) Dprintf("OCT_NON_ZERO\n");
            for(Y=0;Y<2;Y++) for(X=0;X<2;X++)
                KlicsTree(mode,x*2+X,y*2+Y,z,oct-1,sub,channel,ctrl);
        } else if (mode!=VOID) Dprintf("OCT_ZERO\n");
    }
}

void  KlicsLPF(mode,z,ctrl)

CompCtrl  ctrl;
int    mode, z;

{
    Block  addr, old, new, delta;
    int    channel, channels=ctrl->dst->type==MONO?1:3, x, y,
           octs_lum=ctrl->dst->trans.wavelet.space[0],

size[2]={Size(ctrl->dst,0,0)>>octs_lum+1,Size(ctrl->dst,0,1)>>octs_lum+1};

```

- 162 -

```

    for(y=0;y < size[1];y++) for(x=0;x < size[0];x++) {
        Boolean      lpf_loc=True;

        if (mode!=STILL) {
            lpf_loc=BoolToken(ctrl->bfp); /*
LPF_LOC_ZERO/LPF_LOC_NON_ZERO */

        Dprintf("%s\n",lpf_loc?"LPF_LOC_NON_ZERO":"LPF_LOC_ZERO");
        }

        if (lpf_loc) for(channel=0;channel < channels;channel++) {
            int

            octs=ctrl->dst->trans.wavelet.space[ctrl->dst->type==YUV && channel!=0?1:0],
                X, Y, step, value, bits=0;

            double

            norms[3]={ctrl->quant_const,ctrl->thresh_const,ctrl->cmp_const};

            PrevBlock(old,addr,x,y,z,octs-1,0,channel,ctrl);
            CalcNormals(ctrl,octs-1,0,channel,norms);
            step=norms[0] < 1.0?1:(int)norms[0];
            if (mode==STILL) {
                for(bits=0,
value=((1 < < 8+ctrl->dst->precision)-1)/step;value!=0;bits++)
                    value=value > > 1;
                for(X=0;X < BLOCK;X++) for(Y=0;Y < BLOCK;Y++)
                    delta[X][Y]=ReadInt(bits,ctrl->bfp);
                DeltaBlock(new,old,delta,step);
                UpdateBlock(new,addr,z,channel,ctrl);
            } else {
                if (BoolToken(ctrl->bfp)) { /*
LPF_ZERO/LPF_NON_ZERO */

                    Dprintf("LPF_NON_ZERO\n");
                    HuffBlock(delta,ctrl->bfp);

```

- 163 -

```

        DeltaBlock(new,old,delta,step);
        UpdateBlock(new,addr,z,channel,ctrl);
    } else Dprintf("LPF_ZERO\n");
    }
}

}

}

}

void KlicsFrame(ctrl,z)

CompCtrl    ctrl;
int         z;

{
    Video dst=ctrl->dst;
    int    sub, channel, x, y, mode=ctrl->stillvid || z==0?STILL:SEND,
          octs_lum=dst->trans.wavelet.space[0],

size[2]={Size(dst,0,0)>>1+octs_lum,Size(dst,0,1)>>1+octs_lum};

    NewFrame(dst,z);
    CopyFrame(dst,z-1,z,ctrl->stillvid || z==0);
    if (z!=0 && ctrl->auto_q) {

ctrl->quant_const+=(double)(HISTO/2+ReadInt(HISTO_BITS,ctrl->bfp))*HISTO_DE
LTA*2.0/HISTO-HISTO_DELTA;

        ctrl->quant_const=ctrl->quant_const<0.0?0.0:ctrl->quant_const;
        Dprintf("New quant %f\n",ctrl->quant_const);
    }
    KlicsLPF(mode,z,ctrl);
    for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {
        if (BoolToken(ctrl->bfp)) {

```

- 164 -

```

Dprintf("LOCAL_NON_ZERO\n");
for(channel=0;channel < (dst->type == MONO?1:3);channel++) {
    int    octs=dst->trans.wavelet.space[dst->type == YUV
&& channel!=0?1:0];

    if (BoolToken(ctrl->bfp)) {
        Dprintf("CHANNEL_NON_ZERO\n");
        for(sub=1;sub < 4;sub++)
            KlicsTree(mode,x,y,z,octs-1,sub,channel,ctrl);
    } else Dprintf("CHANNEL_ZERO\n");
}
} else Dprintf("LOCAL_ZERO\n");
}
}

```

```

void ImportKlics(w,closure,call_data)

```

```

Widget      w;

```

```

caddr_t     closure, call_data;

```

```

{

```

```

    char    file_name[STRLEN];

```

```

    CompCtrlRec ctrl;

```

```

    int     i, z;

```

```

    ctrl.dst=(Video)MALLOC(sizeof(VideoRec));

```

```

    strcpy(ctrl.bin_name,((XawListReturnStruct *)call_data)->string);

```

```

sprintf(file_name, "%s%s/%s%s\0",global->home,KLICS_DIR,ctrl.bin_name,KLICS_EX
T);

```

```

    ctrl.bfp=bopen(file_name,"r");

```

```

    ReadKlicsHeader(&ctrl);

```

- 165 -

```
if (ctrl.dst->disk) SaveHeader(ctrl.dst);
for(z=0;z<ctrl.dst->size[2];z++) {
    if (z==0 || !ctrl.buf_switch) KlicsFrame(&ctrl,z);
    else {
        if (BoolToken(ctrl.bfp)) KlicsFrame(&ctrl,z);
        else SkipFrame(ctrl.dst,z);
    }
    if (z>0) {
        SaveFrame(ctrl.dst,z-1);
        FreeFrame(ctrl.dst,z-1);
    }
}
SaveFrame(ctrl.dst,ctrl.dst->size[2]-1);
FreeFrame(ctrl.dst,ctrl.dst->size[2]-1);
bclose(ctrl.bfp);
ctrl.dst->next=global->videos;
global->videos=ctrl.dst;
}
```

- 166 -

```
source/ImportKlicsSA.c
```

```
*****/
```

```
/*
```

```
 *   Importing raw Klics binary files
```

```
 *
```

```
 *   Stand Alone version
```

```
*/
```

```
#include    "KlicsSA.h"
```

```
extern void  Convolve();
```

```
/* useful X definitions */
```

```
typedef char  Boolean;
```

```
#define True   1
```

```
#define False  0
```

```
#define String char*
```

```
extern int    HuffReadSA();
```

```
extern Boolean  BlockZeroSA();
```

```
extern void    ZeroCoeffsSA();
```

```
extern int     ReadIntSA();
```

```
extern int     DecideSA();
```

```
extern double   DecideDoubleSA();
```

```
Boolean        BoolTokenSA(bfp)
```

```
Bits    bfp;
```

```
{
```

- 167 -

```
        Boolean    token;

        bread(&token,1,bfp);
        return(token);
    }

void  HuffBlockSA(block,bfp)

Block  block;
Bits   bfp;

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
        block[X][Y]=HuffReadSA(bfp);
}

void  PrevBlockSA(old,addr,x,y,oct,sub,channel,dst)

Block  old, addr;
int    x, y, oct, sub, channel;
short  *dst[3];

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
        addr[X][Y]=AccessSA((x<<1)+X,(y<<1)+Y,oct,sub,channel);
        old[X][Y]=dst[channel][addr[X][Y]];
    }
}
```

- 168 -

```
void DeltaBlockSA(new,old,delta,step)
```

```
Block new, old, delta;
```

```
int step;
```

```
{
```

```
    int X, Y;
```

```
    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
```

```
new[X][Y]=old[X][Y]+delta[X][Y]*step+(delta[X][Y]!=0?negif(delta[X][Y]<0,(step-1)
>>1):0);
```

```
}
```

```
void UpdateBlockSA(new,addr,channel,dst)
```

```
int channel;
```

```
Block new, addr;
```

```
short *dst[3];
```

```
{
```

```
    int X, Y;
```

```
    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
```

```
        dst[channel][addr[X][Y]]=(short)new[X][Y];
```

```
}
```

```
void KlicsTreeSA(mode,x,y,oct,sub,channel,dst,bfp,quant_const)
```

```
int mode, x, y, oct, sub, channel;
```

```
short *dst[3];
```

```
Bits bfp;
```



- 169 -

```

double      quant_const;

{
    Block addr, old, new, delta, zero_block={{0,0},{0,0}};
    double    norms[3]={quant_const,thresh_const,cmp_const};
    int       step;

    PrevBlockSA(old,addr,x,y,oct,sub,channel,dst);
    if (mode!=VOID) {
        CalcNormalsSA(oct,sub,channel,norms,quant_const);
        step=norms[0] < 1.0?1:(int)norms[0];
        if (mode==STILL || BlockZero(old)) {
            if (BoolTokenSA(bfp)) { /* NON_ZERO_STILL */
                Dprintf("NON_ZERO_STILL\n");
                HuffBlockSA(delta,bfp);
                DeltaBlockSA(new,old,delta,step);
                UpdateBlockSA(new,addr,channel,dst);
            } else {
                Dprintf("ZERO_STILL\n");
                mode=STOP; /* ZERO_STILL */
            }
        } else {
            if (!BoolTokenSA(bfp)) { /* BLOCK_SAME */
                Dprintf("BLOCK_SAME\n");
                mode=STOP;
            } else {
                if (!BoolTokenSA(bfp)) { /* ZERO_VID */
                    Dprintf("ZERO_VID\n");
                    ZeroCoeffsSA(dst[channel],addr);
                    mode=VOID;
                } else { /*
BLOCK_CHANGE */

```

- 170 -

```

        Dprintf("BLOCK_CHANGE\n");
        HuffBlockSA(delta,bfp);
        DeltaBlockSA(new,old,delta,step);
        UpdateBlockSA(new,addr,channel,dst);
    }
}
}
} else {
    if (BlockZeroSA(old)) mode=STOP;
    else {
        ZeroCoeffsSA(dst[channel],addr);
        mode=VOID;
    }
}
if (oct>0 && mode!=STOP) {
    Boolean    decend=mode==VOID?True:BoolTokenSA(bfp);
    int    X, Y;

    Dprintf("x=%d, y=%d, oct=%d sub=%d mode
%d\n",x,y,oct,sub,mode);
    if (decend) {
        if (mode!=VOID) Dprintf("OCT_NON_ZERO\n");
        for(Y=0;Y<2;Y++) for(X=0;X<2;X++)

KlicsTreeSA(mode,x*2+X,y*2+Y,oct-1,sub,channel,dst,bfp,quant_const);
    } else if (mode!=VOID) Dprintf("OCT_ZERO\n");
}
}

void  KlicsLPF_SA(mode,dst,bfp,quant_const)

int    mode;

```

- 171 -

```

short  *dst[3];
Bits   bfp;
double  quant_const;

{
    Block addr, old, new, delta;
    int   channel, channels=3, x, y,
          octs_lum=3,

size[2]={SA_WIDTH>>octs_lum+1,SA_HEIGHT>>octs_lum+1};

    for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {
        Boolean   lpf_loc=True;

        if (mode!=STILL) {
            lpf_loc=BoolTokenSA(bfp); /*
LPF_LOC_ZERO/LPF_LOC_NON_ZERO */

Dprintf("%s\n",lpf_loc?"LPF_LOC_NON_ZERO":"LPF_LOC_ZERO");
        }
        if (lpf_loc) for(channel=0;channel<channels;channel++) {
            int   octs=channel!=0?2:3,
                  X, Y, step, value, bits=0;
            double norms[3]={quant_const,thresh_const,cmp_const};

            PrevBlockSA(old,addr,x,y,octs-1,0,channel,dst);
            CalcNormalsSA(octs-1,0,channel,norms,quant_const);
            step=norms[0]<1.0?1:(int)norms[0];
            if (mode==STILL) {
                for(bits=0,
value=((1<<8+SA_PRECISION)-1)/step;value!=0;bits++)
                    value=value>>1;

```

- 172 -

```

        for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
            delta[X][Y]=ReadIntSA(bits,bfp);
        DeltaBlockSA(new,old,delta,step);
        UpdateBlockSA(new,addr,channel,dst);
    } else {
        if (BoolTokenSA(bfp)) { /* LPF_ZERO/LPF_NON_ZERO
*/
            Dprintf("LPF_NON_ZERO\n");
            HuffBlockSA(delta,bfp);
            DeltaBlockSA(new,old,delta,step);
            UpdateBlockSA(new,addr,channel,dst);
        } else Dprintf("LPF_ZERO\n");
    }
}
}
}
}

```

```

void KlicsFrameSA(mode,src,dst,bfp)

```

```

int mode;

```

```

short *src[3], *dst[3];

```

```

Bits bfp;

```

```

{

```

```

    int sub, channel, x, y, i,

```

```

        octs_lum=3,

```

```

size[2]={SA_WIDTH>>1+octs_lum,SA_HEIGHT>>1+octs_lum};

```

```

    double quant_const;

```

```

    bread((char *)&quant_const,sizeof(double)*8,bfp);

```

```

    KlicsLPF_SA(mode,dst,bfp,quant_const);

```

- 173 -

```

for(y=0;y < size[1];y++) for(x=0;x < size[0];x++) {
    if (BoolTokenSA(bfp)) {
        Dprintf("LOCAL_NON_ZERO\n");
        for(channel=0;channel < 3;channel++) {
            int    octs=channel!=0?2:3;

            if (BoolTokenSA(bfp)) {
                Dprintf("CHANNEL_NON_ZERO\n");
                for(sub=1;sub < 4;sub++)
                    KlicsTreeSA(mode,x,y,octs-1,sub,channel,dst,bfp,quant_const);
            } else Dprintf("CHANNEL_ZERO\n");
        }
    } else Dprintf("LOCAL_ZERO\n");
}
for(channel=0;channel < 3;channel++) {
    int
    frame_size[2]={SA_WIDTH>>(channel==0?0:1),SA_HEIGHT>>(channel==0?0:1
    )},

    frame_area=frame_size[0]*frame_size[1];

    for(i=0;i < frame_area;i++) src[channel][i]=dst[channel][i];
    Convolve(src[channel],False,frame_size,channel==0?3:2,0);
    for(i=0;i < frame_area;i++)
        src[channel][i]=src[channel][i]>>SA_PRECISION;
}
}

```

- 174 -

**source/InitFrame.c**

```
/*  
    Initialise frame structure for Frame command widget  
*/  
  
#include    "../include/xwave.h"  
#define     FRAME_ICONS    14  
#define     TRANS_MENU    1  
#define     COMP_MENU     2  
  
extern void  CopyVideo();  
extern void  Compare();  
extern void  NA();  
extern void  FrameDestroy();  
extern void  Examine();  
extern void  FramePointYN();  
extern void  FrameInfo();  
extern void  FrameMerge();  
extern void  Movie();  
extern void  PostScript();  
extern void  Select();  
extern void  Spectrum();  
extern void  NewPoint();  
extern void  Transform();  
extern void  Compress();  
extern String *VideoCurrentList();  
extern void  KlicsSA();  
  
void  InitFrame    (w,closure,call_data)
```

- 175 -

```

Widget      w;
caddr_t     closure, call_data;

{
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
    Video  video=FindVideo(name->string,global->videos);
    Frame frame=(Frame)MALLOC(sizeof(FrameRec));
    Widget      shell[2], form, widgets[FRAME_ICONS],
trans_widgets[TRANS_MENU], comp_widgets[COMP_MENU];
    Arg  args[7];
    Pixmap      pixmap;
    int   view[2]={15+video->size[0],15+video->size[1]};
    FormItem  items[]={
        {"frm_cancel",      "frame_close",          0,0,FW_icon,NULL},
        {"frm_copy", "copy",          1,0,FW_icon,NULL},
        {"frm_exam",      "examine",          2,0,FW_icon,NULL},
        {"frm_point_yn", "point_y",          3,0,FW_icon,NULL},
        {"frm_transform", "transform",
4,0,FW_icon_button,"frm_trans_menu"},
        {"frm_info_yn",      "info",
5,0,FW_icon,NULL},
        {"frm_merge",      "merge",          6,0,FW_toggle,NULL},
        {"frm_compress", "code",
7,0,FW_icon_button,"frm_comp_menu"},
        {"frm_movie",      "movie",          8,0,FW_icon,NULL},
        {"frm_postscript", "postscript",      9,0,FW_icon,NULL},
        {"frm_compare",      "compare",      10,0,FW_icon,NULL},
        {"frm_view", NULL,
0,1,FW_view,(String)view},
        {"frm_label", video->name,          0,12,FW_label,NULL},
        {"frm_colors",      "colors",          13,12,FW_icon,NULL},
    };
};

```

- 176 -

```

Selection    sel=(Selection)MALLOC(sizeof(SelectItem));
MenuItem     trans_menu[TRANS_MENU]={
    {"trans_Wavelet",smeBSBObjectClass,"Wavelet",NULL},
};
MenuItem     comp_menu[COMP_MENU]={
    {"comp_KLICS",smeBSBObjectClass,"KLICS",NULL},
    {"comp_KLICS_SA",smeBSBObjectClass,"KLICS SA",NULL},
};
XtCallbackRec    frame_call[]={
    {FrameDestroy,(caddr_t)frame}, {Free,(caddr_t)sel}, {NULL,NULL},
    {CopyVideo,(caddr_t)video}, {NULL,NULL},
    {Examine,(caddr_t)frame}, {NULL,NULL},
    {FramePointYN,(caddr_t)frame}, {NULL,NULL},
    {FrameInfo,(caddr_t)frame}, {NULL,NULL},
    {FrameMerge,(caddr_t)frame}, {NULL,NULL},
    {Movie,(caddr_t)frame}, {NULL,NULL},
    {PostScript,(caddr_t)frame}, {NULL,NULL},
    {Select,(caddr_t)sel}, {NULL,NULL},
    {Spectrum,(caddr_t)frame}, {NULL,NULL},
}, image_call[]={
    {NewPoint,(caddr_t)frame}, {NULL,NULL},
}, trans_call[]={
    {Transform,(caddr_t)video}, {NULL,NULL},
}, comp_call[]={
    {Compress,(caddr_t)video}, {NULL,NULL},
    {KlicsSA,(caddr_t)video}, {NULL,NULL},
};
Colormap      cmap=ChannelCmap(frame->channel==(video->type==MONO
|| video->trans.type!=TRANS_None)?0:3,video->type,video->gamma);

Dprintf("InitFrame\n");

```



- 177 -

```
sel->name="video_Compare";
sel->button="frm_compare";
sel->list_proc=VideoCurrentList;
sel->action_name="Compare videos";
sel->action_proc=Compare;
sel->action_closure=(caddr_t)video;
frame->video=video;
frame->shell=ShellWidget("frm_shell",global->toplevel,SW_top,cmap,NULL);
form=FormatWidget("frm_form",frame->shell);
frame->image_widget=NULL;

frame->msg=NULL;

frame->zoom=0;
frame->frame=0;

frame->point_switch=False;
frame->point_merge=False;

frame->point=(Point)MALLOC(sizeof(PointRec));
frame->point->location[0]=0;
frame->point->location[1]=0;
frame->point->usage=1;
frame->point->next=global->points;
global->points=frame->point;

frame->palette=0;

frame->next=global->frames;
global->frames=frame;

GetFrame(video,frame->frame);
```

- 178 -

```

    pixmap=UpdateImage(frame);

    FillForm(form,FRAME_ICONS,items,widgets,frame_call);
    shell[0]=ShellWidget("frm_trans_menu",widgets[4],SW_menu,NULL,NULL);
    FillMenu(shell[0],TRANS_MENU,trans_menu,trans_widgets,trans_call);
    shell[1]=ShellWidget("frm_comp_menu",widgets[7],SW_menu,NULL,NULL);
    FillMenu(shell[1],COMP_MENU,comp_menu,comp_widgets,comp_call);

    frame->point_merge_widget=widgets[6];

    XtSetArg(args[0],XtNbitmap,pixmap);
    XtSetArg(args[1],XtNwidth,video->size[0]);
    XtSetArg(args[2],XtNheight,video->size[1]);
    XtSetArg(args[3],XtNcallback,image_call);

    frame->image_widget=XtCreateManagedWidget("frm_image",imageWidgetClass,widget
s[11],args,FOUR);
    XtSetSensitive(frame->image_widget,False);
    XtSetSensitive(widgets[13],PseudoColor==global->visinfo->class);
    XtPopup(frame->shell,XtGrabNone);
}

Video FindVideo(name,video)

String name;
Video video;

{
    if (video==NULL) return(NULL);
    else if (!strcmp(name,video->name)) return(video);
        else return(FindVideo(name,video->next));
}

```

- 179 -

**source/InitMain.c**

```
/*  
    Initialise menu structure for Main command widget  
*/
```

```
#include    "../include/xwave.h"
```

```
/* Save externs */
```

```
extern void  VideoSave();  
extern void  VideoXimSave();  
extern void  VideoDTSave();  
extern void  VideoMacSave();  
extern void  VideoHexSave();
```

```
/* List externs */
```

```
extern String *VideoList();  
extern String *VideoDropList();  
extern String *VideoCurrentList();  
extern String *KlicsList();  
extern String *KlicsListSA();
```

```
/* Import externs */
```

```
extern void  ImportKlics();  
extern void  ImpKlicsTestSA();
```

```
/* Main externs */
```

- 180 -

```

extern void  Select();
extern void  VideoClean();
extern void  Quit();
extern void  VideoLoad();
extern void  InitFrame();
extern void  VideoDrop();
extern void  PlotGraph();

```

```

/*    Function Name:    InitMain
 *    Description:    Create main menu button & sub-menus
 *    Arguments:    none
 *    Returns:    none
 */

```

```

#define      MAIN_MENU      7
#define      SAVE_MENU      5
#define      IMPT_MENU      2

```

```

InitMain()

```

```

{
    Widget      form=FormatWidget("xwave_form",global->toplevel), widgets[1],
                main_shell, main_widgets[MAIN_MENU],
                save_shell, save_widgets[SAVE_MENU],
                impt_shell, impt_widgets[IMPT_MENU];

    FormItem    items[]={
        {"xwaveLogo","main",0,0,FW_icon_button,"xwave_main_sh"},
    };

    MenuItem    main_menu[]={
        {"main_Open",smeBSBObjectClass,"Open a video",NULL},
        {"main_Attach",smeBSBObjectClass,"Attach a frame",NULL},
        {"main_Save",smeBSBprObjectClass,"Save a video","xwave_save_sh"},
    };
}

```

- 181 -

```

        {"main_Drop",smeBSBObjectClass,"Drop a video",NULL},
        {"main_Clean",smeBSBObjectClass,"Clean out videos",NULL},
        {"main_Import",smeBSBprObjectClass,"Import a
video","xwave_impt_sh"},
        {"main_Quit",smeBSBObjectClass,"Quit",NULL},
    }, save_menu[]={
        {"save_menu_vid",smeBSBObjectClass,"Save xwave video",NULL},
        {"save_menu_xim",smeBSBObjectClass,"Save xim video",NULL},
        {"save_menu_dt",smeBSBObjectClass,"Save DT image",NULL},
        {"save_menu_mac",smeBSBObjectClass,"Save mac video",NULL},
        {"save_menu_hex",smeBSBObjectClass,"Save hex dump",NULL},
    }, impt_menu[]={
        {"impt_menu_klics",smeBSBObjectClass,"KLICS",NULL},
        {"impt_menu_klicsSA",smeBSBObjectClass,"KLICS SA",NULL},
    };
    static SelectItem selection[]={
        {"video_Open","xwaveLogo",VideoList,"Open a
video",VideoLoad,NULL},
        {"frame_Attach","xwaveLogo",VideoCurrentList,"Attach a
frame",InitFrame,NULL},
        {"video_Drop","xwaveLogo",VideoDropList,"Drop a
video",VideoDrop,NULL},
    }, save_sel[]={
        {"save_vid","xwaveLogo",VideoCurrentList,"Save xwave
video",VideoSave,NULL},
        {"save_xim","xwaveLogo",VideoCurrentList,"Save xim
video",VideoXimSave,NULL},
        {"save_dt","xwaveLogo",VideoCurrentList,"Save DT
image",VideoDTSave,NULL},
        {"save_mac","xwaveLogo",VideoCurrentList,"Save mac
video",VideoMacSave,NULL},
        {"save_hex","xwaveLogo",VideoCurrentList,"Save hex

```

- 182 -

```

dump",VideoHexSave,NULL},
    }, impt_sel[]={
        {"impt_klics","xwaveLogo",KlicsList,"Import
KLICS",ImportKlics,NULL},
        {"impt_klicsSA","xwaveLogo",KlicsListSA,"Import KLICS
SA",ImpKlicsTestSA,NULL},
    };

XtCallbackRec    main_call[]={
    {Select,(caddr_t)&selection[0]}, {NULL,NULL},
    {Select,(caddr_t)&selection[1]}, {NULL,NULL},
    {Select,(caddr_t)&selection[2]}, {NULL,NULL},
    {VideoClean,(caddr_t)NULL}, {NULL,NULL},
    {Quit,(caddr_t)NULL}, {NULL,NULL},
}, save_call[]={
    {Select,(caddr_t)&save_sel[0]}, {NULL,NULL},
    {Select,(caddr_t)&save_sel[1]}, {NULL,NULL},
    {Select,(caddr_t)&save_sel[2]}, {NULL,NULL},
    {Select,(caddr_t)&save_sel[3]}, {NULL,NULL},
    {Select,(caddr_t)&save_sel[4]}, {NULL,NULL},
}, impt_call[]={
    {Select,(caddr_t)&impt_sel[0]}, {NULL,NULL},
    {Select,(caddr_t)&impt_sel[1]}, {NULL,NULL},
};

Dprintf("InitMain\n");
FillForm(form,ONE,items,widgets,NULL);
main_shell=ShellWidget("xwave_main_sh",widgets[0],SW_menu,NULL,NULL);
save_shell=ShellWidget("xwave_save_sh",main_shell,SW_menu,NULL,NULL);
impt_shell=ShellWidget("xwave_impt_sh",main_shell,SW_menu,NULL,NULL);
FillMenu(main_shell,MAIN_MENU,main_menu,main_widgets,main_call);
FillMenu(save_shell,SAVE_MENU,save_menu,save_widgets,save_call);
FillMenu(impt_shell,IMPT_MENU,impt_menu,impt_widgets,impt_call);
}

```

- 183 -

source/Klics5.c

```

/*
    Full still/video Knowles-Lewis Image Compression System utilising HVS
    properties
    and delta-tree coding
*/

#include "xwave.h"
#include "Klics.h"
#include <math.h>

extern Bits bopen();
extern void bclose(), bread(), bwrite(), bflush();

extern WriteKlicsHeader();

/* token modes (empty) */
#define EMPTY 0
#define CHANNEL_EMPTY 1
#define OCTAVE_EMPTY 2
#define LPF_EMPTY 3
#define FULL 4

typedef struct _HistRec {
    int bits, octbits[3][5], lpf, activity, target, token[TOKENS], coeff[129];
    double q_const;
} HistRec, *Hist; /* history record */

/* Function Name: Access
 * Description: Find index address from co-ordinates

```

- 184 -

```

*   Arguments:  x, y - (x,y) co-ordinates
*
*               oct, sub, channel - octave, sub-band and channel co-ordinates
*
*               width - image data width
*
*   Returns:  index into vid->data[channel][index]
*/

int   Access(x,y,oct,sub,width)

int   x, y, oct, sub, width;

{
    return(((x < < 1)+(sub > > 1)+width*((y < < 1)+(1&sub))) < < oct);
}

/*   Function Name:      LastFrame
*
*   Description:  Find last frame encoded
*
*   Arguments:  z - index of current frame
*
*               hist - history records
*
*   Returns:      index of previous frame
*/

int   LastFrame(z,hist)

int   z;
Hist  hist;

{
    int   i=z-1;

    while(hist[i].bits == 0 && i > 0) i--;
    return(i < 0?0:i);
}

```



- 185 -

```

/*    Function Name:    Decide
 *    Description:    Calculate value representing the difference between new and old
blocks
 *    Arguments:    new, old - blocks to compare
 *
                    mode - differencing algorithm {MAXIMUM | SIGABS |
SIGSQR}
 *    Returns:    difference value
 */

```

```

int    Decide(new,old,mode)

```

```

Block new, old;

```

```

int    mode;

```

```

{
    int    X, Y, sigma=0;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
        int    n_o=new[X][Y]-old[X][Y];

        switch(mode) {
            case MAXIMUM:
                sigma=sigma>abs(n_o)?sigma:abs(n_o);
                break;
            case SIGABS:
                sigma+=abs(n_o);
                break;
            case SIGSQR:
                sigma+=n_o*n_o;
                break;
        }
    }
}

```

- 186 -

```
        return(sigma);
    }

/*  Function Name:    DecideDouble
 *  Description:    Calculates normal w.r.t differencing algorithm
 *  Arguments:    norm - normal value
 *
 *                  mode - differencing algorithm {MAXIMUM | SIGABS |
SIGSQR}
 *  Returns:    new normal value
 */

double    DecideDouble(norm,mode)

double    norm;
int    mode;

{
    double    ret;

    switch(mode) {
    case MAXIMUM:
        ret=norm;
        break;
    case SIGABS:
        ret=4.0*norm;
        break;
    case SIGSQR:
        ret=4.0*norm*norm;
        break;
    }
    return(ret);
}
```

- 187 -

Boolean      Decision(new,old,norm,mode)

Block new, old;

double      norm;

int      mode;

```
{
    return((double)Decide(new,old,mode) <= DecideDouble(norm,mode));
}
```

/\*      Function Name:      Feedback

\*      Description:      Calculates new target activity from target bits and historical values

\*      Arguments:      hist - history records

\*                      curr - current frame

\*                      taps - size of history window

\*      Returns:      target activity

\*/

int      Feedback(hist,curr,taps)

int      curr;

Hist      hist;

int      taps;

```
{
    int      prev=curr, i;
    double      ratio=0;

    for(i=0;i<taps && prev!=0;i++) {
        prev=LastFrame(prev,hist);
```

```
ratio += (double)hist[prev].activity/(double)(hist[prev].bits-(prev==0?hist[0].lpf:0));
```

- 188 -

```

    }
    return((int)(ratio*(double)hist[curr].target/(double)i));
}

/*  Function Name:      Filter
 *
 *  Description:  Calculates new q_const filtering historical values
 *
 *  Arguments:   hist - history records
 *
 *               curr - current frame
 *
 *               taps - size of history window
 *
 *               filter - index to filter
 *
 *  Returns:     q_const
 */

```

```
double      Filter(hist,curr,taps,filter)
```

```
int    curr;
```

```
Hist  hist;
```

```
int    taps, filter;
```

```

{
    double      mac=hist[curr].q_const, sum=1.0, coeff=1.0;
    int    i, prev=curr;

    for(i=0;i<taps && prev!=0;i++) {
        prev=LastFrame(prev,hist);
        coeff=filter==0?0:coeff/2.0;
        mac +=hist[prev].q_const*coeff;
        sum +=coeff;
    }
    return(mac/sum);
}

```

- 189 -

```

/*  Function Name:    Huffman
 *  Description:    Calculates the number of bits for the Huffman code representing
level
 *  Arguments:    level - level to be encoded
 *  Returns:      number of bits in codeword
 */

```

```

int  Huffman(level)

```

```

int  level;

```

```

{
    return(level == 0?2:(abs(level) < 3?3:1 + abs(level)));
}

```

```

/*  Function Name:    HuffCode
 *  Description:    Generates Huffman code representing level
 *  Arguments:    level - level to be encoded
 *  Returns:      coded bits in char's
 */

```

```

unsigned char *HuffCode(level)

```

```

int  level;

```

```

{
    unsigned char *bytes=(unsigned char *)MALLOC((7+Huffman(level))/8);

    bytes[0]=(abs(level) < 3?abs(level):3)|(level < 0?4:0);
    if (abs(level) > 2) {
        int  index=(7+Huffman(level))/8-1;

```

- 190 -

```
        bytes[index]=bytes[index]|(1 << (Huffman(level)-1)%8);
    }
    return(bytes);
}
```

unsigned char \*CodeInt(number,bits)

```
int    number, bits;

{
    int    len=(7+bits)/8;
    unsigned char *bytes=(unsigned char *)MALLOC(len);
    int    byte;

    for(byte=0;byte<len;byte++) {
        bytes[byte]=0xff&number;
        number=number >> 8;
    }
    return(bytes);
}
```

int ReadInt(bits,bfp)

```
int    bits;
Bits   bfp;

{
    int    len=(7+bits)/8;
    unsigned char bytes[len];
    int    byte, number=0;

    bread(bytes,bits,bfp);
```

- 191 -

```

    for(byte=0;byte<len;byte++)
        number=number|((int)bytes[byte]<<byte*8);
    number=(number<<sizeof(int)*8-bits)>>sizeof(int)*8-bits;
    return(number);
}

/*  Function Name:      HuffRead
 *  Description:  Read Huffman encoded number from binary file
 *  Arguments:   bfp - binary file pointer
 *  Returns:     decoded level
 */

int  HuffRead(bfp)

Bits  bfp;

{
    int  value;
    unsigned char  byte;
    Boolean  negative=False;

    bread(&byte,2,bfp);
    value=(int)byte;
    if (byte=='\0') return(0);
    else {
        bread(&byte,1,bfp);
        negative=(byte!='\0');
    }
    if (value<3) return(negif(negative,value));
    for(byte='\0';byte=='\0';value++) bread(&byte,1,bfp);
    return(negif(negative,value-1));
}

```

- 192 -

```

/*  Function Name:    Quantize
*   Description:    RM8 style quantizer
*   Arguments:    data - unquantised number
*                  q - quantizing divisor
*                  level - quantised to level
*   Returns:      quantized data & level
*/

int  Quantize(data,q,level)

int  data, q, *level;

{
    int  mag_level=abs(data)/q;

    *level=negif(data<0,mag_level);
    return(negif(data<0,mag_level*q+(mag_level!=0?(q-1)>>1:0)));
}

/*  Function Name:    Proposed
*   Description:    Calculates proposed block values
*   Arguments:    pro - proposed block
*                  lev - proposed block quantized levels
*                  old, new - old and new block values
*                  decide - decision algorithm
*                  norms - HVS normals
*   Returns:      new ==0, proposed values (pro) and levels (lev)
*/

```

Boolean      Proposed(pro,lev,old,new,decide,norms)

Block pro, lev, old, new;



- 193 -

```

int    decide;
double    norms[3];

{
    Block zero_block={{0,0},{0,0}};
    int    X, Y, step=norms[0] < 1.0?1:(int)norms[0];
    Boolean    zero=Decision(new,zero_block,norms[1],decide);

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)

pro[X][Y]=zero?0:old[X][Y]+Quantize(new[X][Y]-old[X][Y],step,&(lev[X][Y]));
    return(zero);
}

```

```

/*    Function Name:    ZeroCoeffs
*    Description:    Zero out video data
*    Arguments:    data - image data
*                  addr - addresses
*    Returns:    zeros data[addr[][]]
*/

```

```

void    ZeroCoeffs(data,addr)

```

```

short    *data;
Block    addr;

```

```

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
        data[addr[X][Y]]=0;
}

```

- 194 -

```

/*    Function Name:    BlockZero
*    Description:    Test if all block values are zero
*    Arguments:    block - block under test
*    Returns:    block == 0
*/

```

```

Boolean    BlockZero(block)

```

```

Block block;

```

```

{
    int    X, Y;
    Boolean    zero = True;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
        if (block[X][Y]!=0) zero=False;
    return(zero);
}

```

```

/*    Function Name:    SendToken
*    Description:    Increments token frequency
*    Arguments:    token - token to be transmitted
*                  channel, sub, oct - co-ordinates
*                  ctrl - control record for compression
*                  hist - history record
*                  empty - zero state {EMPTY | CHANNEL_EMPTY |
OCTAVE_EMPTY | LPF_EMPTY | FULL}
*                  branch - branch of tree (0-3)
*    Returns:    encodes token
*/

```

```

void    SendToken(token,channel,sub,oct,ctrl,hist,empty,branch)

```

- 195 -

```

int    token, channel, sub, oct, *empty, branch;
CompCtrl  ctrl;
Hist  hist;

{
    int    full=FULL, i;
    String
token_name[TOKENS]={ "ZERO_STILL", "NON_ZERO_STILL", "BLOCK_SAME", "ZE
RO_VID", "BLOCK_CHANGE",

"LOCAL_ZERO", "LOCAL_NON_ZERO", "CHANNEL_ZERO", "CHANNEL_NON_ZE
RO", "OCT_ZERO", "OCT_NON_ZERO",

"LPF_ZERO", "LPF_NON_ZERO", "LPF_LOC_ZERO", "LPF_LOC_NON_ZERO"};

    switch(*empty) {
    case EMPTY:
        if (token!=ZERO_STILL && token!=BLOCK_SAME) {

SendToken(LOCAL_NON_ZERO,channel,sub,oct,ctrl,hist,&full,branch);
            for(i=0;i<channel;i++)
SendToken(CHANNEL_ZERO,i,sub,oct,ctrl,hist,&full,branch);
                *empty=CHANNEL_EMPTY;
                SendToken(token,channel,sub,oct,ctrl,hist,empty,branch);
            }
            break;
        case CHANNEL_EMPTY:
            if (token!=ZERO_STILL && token!=BLOCK_SAME) {

SendToken(CHANNEL_NON_ZERO,channel,sub,oct,ctrl,hist,&full,branch);
                for(i=1;i<sub;i++)
SendToken(token==NON_ZERO_STILL?ZERO_STILL:BLOCK_SAME,channel,i,oct,ct

```

- 196 -

```

    rl,hist,&full,branch);
        *empty = FULL;
        SendToken(token,channel,sub,oct,ctrl,hist,empty,branch);
    }
    break;
case OCTAVE_EMPTY:
    if (token!=ZERO_STILL && token!=BLOCK_SAME) {

SendToken(OCT_NON_ZERO,channel,sub,oct,ctrl,hist,&full,branch);
        for(i=0;i < branch;i++)
SendToken(token==NON_ZERO_STILL?ZERO_STILL:BLOCK_SAME,channel,sub,oct,ctrl,hist,&full,branch);
        *empty = FULL;
        SendToken(token,channel,sub,oct,ctrl,hist,empty,branch);
    }
    break;
case LPF_EMPTY:
    if (token!=LPF_ZERO) {

SendToken(LPF_LOC_NON_ZERO,channel,sub,oct,ctrl,hist,&full,branch);
        for(i=0;i < channel;i++)
SendToken(LPF_ZERO,i,sub,oct,ctrl,hist,&full,branch);
        *empty = FULL;
        SendToken(token,channel,sub,oct,ctrl,hist,empty,branch);
    }
    break;
case FULL:
    Dprintf("%s\n",token_name[token]);
    hist->token[token]++;
    hist->bits+=token_bits[token];
    hist->octbits[channel][oct]+=token_bits[token];
    if (ctrl->bin_switch)

```

- 197 -

```

bwrite(&token_codes[token],token_bits[token],ctrl->bfp);
    break;

```

```

    }
}

```

```

/*    Function Name:    ReadBlock
*    Description:    Read block from video
*    Arguments:    new, old, addr - new and old blocks and addresses
*                  x, y, z, oct, sub, channel - co-ordinates of block
*                  ctrl - compression control record
*    Returns:    block values
*/

```

```

void    ReadBlock(new,old,addr,x,y,z,oct,sub,channel,ctrl)

```

```

Block new, old, addr;

```

```

int    x, y, z, oct, sub, channel;

```

```

CompCtrl    ctrl;

```

```

{

```

```

    int    X, Y;

```

```

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {

```

```

        addr[X][Y]=Access((x<<1)+X,(y<<1)+Y,oct,sub,Size(ctrl->src,channel,0));

```

```

            new[X][Y]=(int)ctrl->src->data[channel][z][addr[X][Y]];

```

```

            old[X][Y]=(int)ctrl->dst->data[channel][z][addr[X][Y]];

```

```

        }

```

```

    }

```

```

/*    Function Name:    CalcNormals

```

```

*    Description:    Calculates HVS weighted normals

```

- 198 -

```

*   Arguments:  ctrl - compression control record
*
*                   oct, sub, channel - co-ordinates
*
*                   norms - pre-initialised normals
*
*   Returns:    weighted normals
*/

void  CalcNormals(ctrl,oct,sub,channel,norms)

CompCtrl  ctrl;
int  oct, sub, channel;
double  norms[3];

{
    Video vid=ctrl->dst;
    int  norm, base_oct=oct+(vid->type==YUV &&
channel!=0?vid->trans.wavelet.space[0]-vid->trans.wavelet.space[1]:0)+(sub==0?1:0)
;

    for(norm=0;norm<3;norm++) {
        if (norm!=0) norms[norm] *= ctrl->quant_const;
        norms[norm] *=
ctrl->base_factors[base_oct]*(sub==3?ctrl->diag_factor:1.0);
        if (channel!=0) norms[norm] *= ctrl->chrome_factor;
        norms[norm] *=(double)(1<<vid->precision);
    }
}

/*   Function Name:    MakeDecisions
*
*   Description:  Decide on new compression mode from block values
*
*   Arguments:  old, new, pro - block values
*
*                   zero - zero flag for new block
*
*                   norms - HVS normals

```

- 199 -

```

*           mode - current compression mode
*           decide - comparison algorithm
*   Returns:   new compression mode
*/

```

```

int   MakeDecisions(old,new,pro,zero,norms,mode,decide)

```

```

Block new, old, pro;
Boolean   zero;
double    norms[3];
int   mode, decide;

{
    Block zero_block={{0,0},{0,0}};
    int   new_mode, np=Decide(new,pro,decide), no=Decide(new,old,decide);

    if (np<no && (double)no>DecideDouble(norms[mode]==STILL?1:2],decide)
    && !zero)
        new_mode=mode==STILL ||
(double)Decide(old,zero_block,decide)<=DecideDouble(norms[1],decide)?STILL:SEND;
    else new_mode=mode==SEND && np<no && zero?VOID:STOP;
    return(new_mode);
}

```

```

int   MakeDecisions2(old,new,pro,lev,zero,norms,mode,decide)

```

```

Block new, old, pro, lev;
Boolean   zero;
double    norms[3];
int   mode, decide;

{

```

- 200 -

```

Block zero_block={{0,0},{0,0}};
int    new_mode=mode==STILL || BlockZero(old)?STILL:SEND,
        np=Decide(new,pro,decide), no=Decide(new,old,decide);

    if (new_mode==STILL) new_mode=np>=no || zero ||
BlockZero(lev)?STOP:STILL;
    else new_mode=zero && np<no?VOID:np>=no ||
Decision(new,old,norms[2],decide) || BlockZero(lev)?STOP:SEND;
    return(new_mode);
}

```

```

/*  Function Name:      UpdateCoeffs
*   Description:  Encode proposed values and write data
*   Arguments:   pro, lev, addr - proposed block, levels and addresses
*               z, channel, oct - co-ordinates
*               ctrl - compression control record
*               hist - history record
*   Returns:     alters ctrl->dst->data[channel][z][addr[]]
*/

```

```

void  UpdateCoeffs(pro,lev,addr,z,channel,oct,ctrl,hist)

```

```

Block pro, lev, addr;
int    z, channel, oct;
CompCtrl ctrl;
Hist   hist;

```

```

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
        int    bits=Huffman(lev[X][Y]),

```



- 201 -

```

        level=abs(lev[X][Y]);

        ctrl->dst->data[channel][z][addr[X][Y]]=(short)pro[X][Y];
        hist->coeff[level>128?128:level]++;
        hist->bits+=bits;
        hist->octbits[channel][oct]+=bits;
        if (ctrl->bin_switch) {
            unsigned char    *bytes=HuffCode(lev[X][Y]);

            bwrite(bytes,bits,ctrl->bfp);
            XtFree(bytes);
        }
    }
}

/*  Function Name:    SendTree
 *  Description:    Encode tree blocks
 *  Arguments:    prev_mode - compression mode
 *                x, y, z, oct, sub, channel - co-ordinates
 *                ctrl - compression control record
 *                hist - history records
 *                empty - token mode
 *                branch - tree branch number
 *  Returns:    active block indicator
 */

Boolean    SendTree(prev_mode,x,y,z,oct,sub,channel,ctrl,hist,empty,branch)

int    prev_mode, x, y, z, oct, sub, channel, *empty, branch;
CompCtrl    ctrl;
Hist    hist;

```

- 202 -

```

{
    Block  addr, old, new, pro, lev;
    int    new_mode, X, Y;
    double

norms[3]={ctrl->quant_const,ctrl->thresh_const,ctrl->cmp_const}; /* quant, thresh,
compare */
    Boolean    active=False;

    ReadBlock(new,old,addr,x,y,z,oct,sub,channel,ctrl);
    if (prev_mode!=VOID) {
        Boolean    zero;

        CalcNormals(ctrl,oct,sub,channel,norms);
        zero=Proposed(pro,lev,old,new,ctrl->decide,norms);
/*
new_mode=MakeDecisions(old,new,pro,zero,norms,prev_mode,ctrl->decide);*/

new_mode=MakeDecisions2(old,new,pro,lev,zero,norms,prev_mode,ctrl->decide);
        switch(new_mode) {
            case STOP:

/*SendToken(prev_mode==STILL?ZERO_STILL:BLOCK_SAME,channel,sub,oct,ctrl,h
ist,empty,branch);*/
                SendToken(prev_mode==STILL ||
BlockZero(old)?ZERO_STILL:BLOCK_SAME,channel,sub,oct,ctrl,hist,empty,branch);
                break;
            case STILL:
            case SEND:
                active=True;

/*SendToken(prev_mode==STILL?NON_ZERO_STILL:BLOCK_CHANGE,channel,sub
,oct,ctrl,hist,empty,branch);*/

```

- 203 -

```

        SendToken(prev_mode == STILL ||
BlockZero(old)?NON_ZERO_STILL:BLOCK_CHANGE,channel,sub,oct,ctrl,hist,empty,
branch);

        UpdateCoeffs(pro,lev,addr,z,channel,oct,ctrl,hist);
        break;
    case VOID:
        SendToken(ZERO_VID,channel,sub,oct,ctrl,hist,empty,branch);
        ZeroCoeffs(ctrl->dst->data[channel][z],addr);
        break;
    }
} else {
    if (BlockZero(old)) new_mode=STOP;
    else {
        ZeroCoeffs(ctrl->dst->data[channel][z],addr);
        new_mode=VOID;
    }
}

if (oct>0 && new_mode!=STOP) {
    int    mt=OCTAVE_EMPTY, full=FULL;

    Dprintf("x=%d, y=%d, oct=%d sub=%d mode
%d\n",x,y,oct,sub,new_mode);
    for(Y=0;Y<2;Y++) for(X=0;X<2;X++)

(void)SendTree(new_mode,x*2+X,y*2+Y,z,oct-1,sub,channel,ctrl,hist,&mt,X+2*Y);
    if (mt==OCTAVE_EMPTY && new_mode!=VOID)
SendToken(OCT_ZERO,channel,sub,oct,ctrl,hist,&full,0);
}

return(active);
}

/*    Function Name:    SendLPF

```

- 204 -

```

*   Description:  Encode LPF sub-band
*   Arguments:   mode - compression mode
*                z -    frame number
*                ctrl - compression control record
*                hist - history records
*   Returns:     encodes data
*/

```

```
void  SendLPF(mode,z,ctrl,hist)
```

```
CompCtrl  ctrl;
```

```
int  mode, z;
```

```
Hist  hist;
```

```
{
```

```
    Block  new, old, pro, lev, addr;
```

```
    int    channel, channels=ctrl->src->type==MONO?1:3, x, y, full=FULL,
           octs_lum=ctrl->src->trans.wavelet.space[0],
```

```
    size[2]={Size(ctrl->src,0,0)>>octs_lum+1,Size(ctrl->src,0,1)>>octs_lum+1};
```

```
    for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {
```

```
        int    empty=LPF_EMPTY;
```

```
        for(channel=0;channel<channels;channel++) {
```

```
            int    octs=ctrl->src->trans.wavelet.space[ctrl->src->type==YUV
&& channel!=0?1:0],
```

```
                new_mode, X, Y, step, value, bits=0;
```

```
                double
```

```
norms[3]={ctrl->quant_const,ctrl->thresh_const,ctrl->cmp_const};
```

```
        CalcNormals(ctrl,octs-1,0,channel,norms);
```

- 205 -

```

        step=norms[0] < 1.0?1:(int)norms[0];
        for(bits=0,
value=((1 < < 8+ctrl->dst->precision)-1)/step;value!=0;bits++)
            value=value > > 1;
        ReadBlock(new,old,addr,x,y,z,octs-1,0,channel,ctrl);

        /* Proposed */
        for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)

pro[X][Y]=old[X][Y]+Quantize(new[X][Y]-old[X][Y],step,&(lev[X][Y]));

        /* MakeDecisions */

new_mode=mode==STILL?STILL:Decision(new,old,norms[2],ctrl->decide) ||
BlockZero(lev)?STOP:SEND;

        switch(new_mode) {
        case SEND:
            SendToken(LPF_NON_ZERO,channel,0,octs,ctrl,hist,&empty,0);
            UpdateCoeffs(pro,lev,addr,z,channel,octs,ctrl,hist);
            break;
        case STILL:
            for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
                ctrl->dst->data[channel][z][addr[X][Y]]=(short)pro[X][Y];
                hist->bits+=bits;
                hist->octbits[channel][octs]+=bits;
                if (ctrl->bin_switch) {
                    unsigned char *bytes=CodeInt(lev[X][Y],bits);

                    bwrite(bytes,bits,ctrl->bfp);
                    XtFree(bytes);
                }
            }

```

- 206 -

```

        }
        break;
    case STOP:
        SendToken(LPF_ZERO,channel,0,octs,ctrl,hist,&empty,0);
        break;
    }
}
if (mode!=STILL && empty==LPF_EMPTY)
SendToken(LPF_LOC_ZERO,channel,0,octs_lum,ctrl,hist,&full,0);
}
hist->lpf=hist->bits;
}

```

```

/*  Function Name:    LookAhead
*   Description:    Examine base of tree to calculate new quantizer value
*   Arguments:    z - frame number
*                  ctrl - compression control record
*                  hist - history records
*   Returns:    calculates new ctrl->quant_const
*/

```

```
void LookAhead(z,ctrl,hist)
```

```
CompCtrl    ctrl;
```

```
int    z;
```

```
Hist    hist;
```

```
{
```

```

    int    x, y, sub, index, thresh[HISTO], decide=ctrl->decide, act,
           taract=Feedback(hist,z.ctrl->feedback),
           octs=ctrl->src->trans.wavelet.space[0],

```

- 207 -

```

size[2]={Size(ctrl->src,0,0)>>1+octs,Size(ctrl->src,0,1)>>1+octs};
    Block new, old, addr;
    double      old_quant=ctrl->quant_const;

    ctrl->quant_const=1.0;
    for(index=0;index<HISTO;index++) thresh[index]=0;
    for(y=0;y<size[1];y++) for(x=0;x<size[0];x++)
for(sub=1;sub<4;sub++) {
        double      q_thresh[3],
norms[3]={ctrl->quant_const,ctrl->thresh_const,ctrl->cmp_const};
        Block zero_block={{0,0},{0,0}};

        ReadBlock(new,old,addr,x,y,z,octs-1,sub,0,ctrl);
        CalcNormals(ctrl,octs-1,sub,0,norms);

q_thresh[1]=(double)Decide(new,zero_block,decide)/DecideDouble(norms[1],decide);

q_thresh[2]=(double)Decide(new,old,decide)/DecideDouble(norms[2],decide);
        if (BlockZero(old)) q_thresh[0]=q_thresh[1];
        else q_thresh[0]=q_thresh[2]<q_thresh[1]?q_thresh[2]:q_thresh[1];
        if (ctrl->decide==SIGSQR) q_thresh[0]=sqrt(q_thresh[0]);

index=(int)((q_thresh[0]-old_quant+HISTO_DELTA)*HISTO/(HISTO_DELTA*2));
        index=index<0?0:index>HISTO-1?HISTO-1:index;
        thresh[index]++;
    }
    for(index=HISTO-1, act=0;index>=0 && act<taract;index--)
act+=thresh[index];

ctrl->quant_const=(double)(index+1)*HISTO_DELTA*2.0/HISTO+old_quant-HISTO_
DELTA;

ctrl->quant_const=ctrl->quant_const<0.0?0.0:ctrl->quant_const;

```

- 208 -

```

    Dprintf("Target bits %d act %d (real %d) adjust q_const to
    %3.2f\n", hist[z].target, taract, act, ctrl->quant_const);
    hist[z].q_const = ctrl->quant_const;
    ctrl->quant_const = Filter(hist, z, ctrl->feedback, ctrl->filter);
    Dprintf("Post filtering q_const to %3.2f\n", ctrl->quant_const);
    if (ctrl->bin_switch) {
        unsigned char *bytes = CodeInt(index + 1 - HISTO/2, HISTO_BITS);

        bwrite(bytes, HISTO_BITS, ctrl->bfp);
        XtFree(bytes);
    }
}

```

```

/*  Function Name:    CompressStats
*   Description:    Compile compression statistics
*   Arguments:    ctrl - compression control record
*                  hist - history records
*   Returns:    plot graphs
*/

```

```
void CompressStats(ctrl, hist)
```

```
CompCtrl ctrl;
```

```
Hist hist;
```

```

{
    FILE *fp_token, *fp_coeff, *fp_log, *fopen();
    char file_name[STRLEN];
    int channel, z, i, sigma;

```

```
sprintf(file_name, "%s%s/%s.token%s\0", global->home, PLOT_DIR, ctrl->stats_name, P
```



- 209 -

```

LOT_EXT);
    fp_token=fopen(file_name,"w");

    sprintf(file_name,"%s%s/%s.coeff%s\0",global->home,PLOT_DIR,ctrl->stats_name,PL
OT_EXT);
    fp_coeff=fopen(file_name,"w");

    sprintf(file_name,"%s%s/%s.log%s\0",global->home,PLOT_DIR,ctrl->stats_name,PLO
T_EXT);
    fp_log=fopen(file_name,"w");
    fprintf(fp_token,"\nTokens %s\n",ctrl->name);
    for(i=0;i<TOKENS;i++) {
        sigma=0;
        for(z=0;z<ctrl->src->size[2];z++) sigma += hist[z].token[i];
        fprintf(fp_token,"%d %d\n",i,sigma);
    }
    fprintf(fp_coeff,"\nCoeffs %s\n",ctrl->name);
    for(i=0;i<129;i++) {
        sigma=0;
        for(z=0;z<ctrl->src->size[2];z++) sigma += hist[z].coeff[i];
        fprintf(fp_coeff,"%d %d\n",i,sigma);
    }
    for(i=0;i<5;i++) {
        String titles[5]={"treebits","activity","quant","bits","ratio"};

        fprintf(fp_log,"\n\n%s\n",titles[i]);
        for(z=0;z<ctrl->src->size[2];z++)
            switch(i) {
                case 0: fprintf(fp_log,"%d %d\n",z,hist[z].bits-hist[z].lpf);
                        break;
                case 1: fprintf(fp_log,"%d %d\n",z,hist[z].activity);
                        break;

```

- 210 -

```

        case 2: fprintf(fp_log, "%d %f\n", z, hist[z].q_const);
                break;
        case 3:  fprintf(fp_log, "%d %d\n", z, hist[z].bits);
                break;
        case 4:  fprintf(fp_log, "%d
%f\n", z, (double)(hist[z].bits-(z==0?hist[z].lpf:0))/(double)hist[z].activity);
                break;
    }
}

for(channel=0; channel < (ctrl->src->type==MONO?1:3); channel++) {
    int    octs=ctrl->src->trans.wavelet.space[ctrl->src->type==YUV
&& channel!=0?1:0];

    for(i=0; i<=octs; i++) {
        fprintf(fp_log, "\n"channel %d oct %d\n", channel, i);
        for(z=0; z<ctrl->src->size[2]; z++)
            fprintf(fp_log, "%d %d\n", z, hist[z].octbits[channel][i]);
    }
}

fclose(fp_token); fclose(fp_coeff); fclose(fp_log);
}

```

```

/*      Function Name:      CopyFrame
*      Description:  Copy frame or zero
*      Arguments:   vid - video
*
*                  from, to - source and destination frame numbers
*                  zero - zero out flag
*      Returns:      alters video->data
*/

```

```
void CopyFrame(vid, from, to, zero)
```

- 211 -

```

Video vid;
int    from, to;
Boolean    zero;

{
    int    i, channel;

    for(channel=0;channel < (vid->type == MONO?1:3);channel++) {
        int    size=Size(vid,channel,0)*Size(vid,channel,1);

        for(i=0;i < size;i++)
            vid->data[channel][to][i]=zero?0:vid->data[channel][from][i];
    }
}

```

```

/*    Function Name:    CompressFrame
*    Description:    Compress a Frame
*    Arguments:    ctrl - compression control record
*                  z - frame number
*                  hist - history records
*                  target - target bits
*/

```

```

void    CompressFrame(ctrl,z,hist,target)

```

```

CompCtrl    ctrl;
int    z, target;
Hist    hist;

{
    Video    src=ctrl->src, dst=ctrl->dst;
    int    sub, channel, x, y, mode=ctrl->stillvid || z==0?STILL:SEND,

```

- 212 -

```

        octs_lum=src->trans.wavelet.space[0],

size[2]={Size(src,0,0)>>1+octs_lum,Size(src,0,1)>>1+octs_lum};

NewFrame(dst,z);
CopyFrame(dst,z-1,z,ctrl->stillvid || z==0);
GetFrame(src,z);
hist[z].target=target;
if (z!=0 && ctrl->auto_q) LookAhead(z,ctrl,hist);
SendLPF(mode,z,ctrl,&hist[z]);
Dprintf("LPF bits %d\n",hist[z].lpf);
hist[z].q_const=ctrl->quant_const;
for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {
    int    empty=EMPTY, full=FULL;

    for(channel=0;channel<(dst->type==MONO?1:3);channel++) {
        int    octs=src->trans.wavelet.space[src->type==YUV &&
channel!=0?1:0];

        for(sub=1;sub<4;sub++) {
            Boolean
active=SendTree(mode,x,y,z,octs-1,sub,channel,ctrl,&hist[z],&empty,0);

            hist[z].activity+=channel==0 && active;
        }
        switch(empty) {
        case FULL:
            empty=CHANNEL_EMPTY;
            break;
        case CHANNEL_EMPTY:
            SendToken(CHANNEL_ZERO,channel,sub,octs-1,ctrl,&hist[z],&full,0)
            break;

```

- 213 -

```

        }
    }
    if (empty == EMPTY)
SendToken(LOCAL_ZERO,channel,sub,octs_lum-1,ctrl,&hist[z],&full,0);
    }
    Dprintf("Activity: %d\n",hist[z].activity);
    FreeFrame(src,z);
}

```

```

/*    Function Name:    SkipFrame
*    Description:    Shuffle frame data as if current frame was skipped
*    Arguments:    vid - video
*                  z - frame number
*    Returns:    alters vid->data
*/

```

```
void    SkipFrame(vid,z)
```

```
Video    vid;
```

```
int    z;
```

```

{
    NewFrame(vid,z);
    CopyFrame(vid,z-1,z,False);
    if (z > 1) {
        GetFrame(vid,z-2);
        CopyFrame(vid,z-2,z-1,False);
        FreeFrame(vid,z-2);
    }
}

```

```
/*    Function Name:    CompressCtrl
```

- 214 -

```

*   Description:  Perform KLICS on a video
*   Arguments:   w - Xaw widget
*
*                   closure - compression control record
*                   call_data - NULL
*   Returns:     compressed video
*/

```

```
void CompressCtrl(w,closure,call_data)
```

```

Widget      w;
caddr_t     closure, call_data;

{
    CompCtrl  ctrl=(CompCtrl)closure;
    int       sigma_bits, frame_count, z, i, buffer=0, frames=ctrl->src->size[2],
            bpf_in=(64000*ctrl->bitrate)/ctrl->src->rate,
            bpf_out=(int)((double)(64000*ctrl->bitrate)/ctrl->fps);
    FILE      *fopen();
    char      file_name[STRLEN];
    HistRec    hist[frames];
    Message    msg=NewMessage(NULL,60);

    msg->rows=frames > 10?11:frames+(frames==1?0:1); msg->cols=30;
    if (global->batch==NULL) {
        XtCallbackRec    callbacks[]={
            {CloseMessage,(caddr_t)msg}, {NULL,NULL},
        };

        MessageWindow(FindWidget("frm_compress",w),msg,"KLICS",True,callbacks);
    }
    Dprintf("CompressCtrl\n");
}

```

- 215 -

```

    if (ctrl->src->type == YUV &&
(ctrl->src->trans.wavelet.space[0] != ctrl->src->trans.wavelet.space[1] + ctrl->src->U
Vsample[0] || ctrl->src->UVsample[0] != ctrl->src->UVsample[1])) {
        Eprintf("Y-UV octaves mis-matched. Check UV-sample");
        return;
    }
    ctrl->dst = CopyHeader(ctrl->src);
    strcpy(ctrl->dst->name, ctrl->name);
    if (ctrl->dst->disk) SaveHeader(ctrl->dst);
    if (ctrl->bin_switch) {

sprintf(file_name, "%s%s/%s%s\\0", global->home, KLICS_DIR, ctrl->bin_name, KLICS_
EXT);

        ctrl->bfp = bopen(file_name, "w");
        /* Write some sort of header */
        WriteKlicsHeader(ctrl);
    }
    for(z=0; z < frames; z++) {
        hist[z].bits = 0;
        hist[z].lpf = 0;
        hist[z].activity = 0;
        hist[z].target = 0;
        for(i=0; i < 5; i++) hist[z].octbits[0][i] = 0;
        for(i=0; i < 5; i++) hist[z].octbits[1][i] = 0;
        for(i=0; i < 5; i++) hist[z].octbits[2][i] = 0;
        for(i=0; i < TOKENS; i++) hist[z].token[i] = 0;
        for(i=0; i < 129; i++) hist[z].coeff[i] = 0;
        hist[z].q_const = 0.0;
    }
    for(z=0; z < frames; z++) {
        if (z == 0 || !ctrl->buf_switch) {
            CompressFrame(ctrl, z, hist, bpf_out);

```

- 216 -

```

        buffer=3200*ctrl->bitrate+bpf_in;
    } else {
        Boolean    no_skip;

        buffer-=bpf_in;
        buffer=buffer<0?0:buffer;
        no_skip=buffer<6400*ctrl->bitrate; /* H.261 buffer size */
        if (ctrl->bin_switch) bwrite(&no_skip,1,ctrl->bfp);
        if (no_skip) {
            CompressFrame(ctrl,z,hist,bpf_out/*+bpf_out/2-buffer*/);
            buffer+=hist[z].bits;
        } else SkipFrame(ctrl->dst,z);
    }
    if (z>0) {
        SaveFrame(ctrl->dst,z-1);
        FreeFrame(ctrl->dst,z-1);
    }
    Mprintf(msg,"%s%03d: %d
bits\n",ctrl->dst->name,z+ctrl->src->start,hist[z].bits);
    Mflush(msg);
}

SaveFrame(ctrl->dst,ctrl->src->size[2]-1);
FreeFrame(ctrl->dst,ctrl->src->size[2]-1);
if (ctrl->bin_switch) { bflush(ctrl->bfp); bclose(ctrl->bfp); }
if (ctrl->stats_switch) CompressStats(ctrl,hist);
Dprintf("Compression Complete\n");
sigma_bits=0, frame_count=0;
for(z=0;z<ctrl->src->size[2];z++) {
    sigma_bits+=hist[z].bits;
    if (hist[z].bits!=0) frame_count++;
}
if (ctrl->buf_switch) {

```



- 217 -

```

        Dprintf("Buffer contains %d bits\n",buffer-bpf_in);
        Dprintf("Frame Rate %4.1f
Hz\n",(double)(ctrl->src->rate*(frame_count-1))/(double)(ctrl->src->size[2]-1));
    }
    if (frames > 1) {
        Mprintf(msg,"Total: %d bits\n",sigma_bits);
        Mflush(msg);
    }
    ctrl->dst->next=global->videos;
    global->videos=ctrl->dst;
}

/*  Function Name:      BatchCompCtrl
 *  Description:  Batch interface to CompressCtrl
 */

void  BatchCompCtrl(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    CompCtrl  ctrl=(CompCtrl)closure;

    if (ctrl->src == NULL) ctrl->src=FindVideo(ctrl->src_name,global->videos);
    CompressCtrl(w,closure,call_data);
}

/*  Function Name:      InitCompCtrl
 *  Description:  Initialise the compression control record
 *  Arguments:  name - name of the source video
 *  Returns:    compression control record

```

- 218 -

\*/

```
CompCtrl    InitCompCtrl(name)
```

```
String name;
```

```
{
```

```
    CompCtrl    ctrl=(CompCtrl)MALLOC(sizeof(CompCtrlRec));
```

```
    int    i;
```

```
    ctrl->decide=SIGABS;
```

```
    ctrl->feedback=4;
```

```
    ctrl->filter=0;
```

```
    ctrl->stillvid=True;
```

```
    ctrl->stats_switch=False;
```

```
    ctrl->auto_q=True;
```

```
    ctrl->buf_switch=True;
```

```
    ctrl->bin_switch=False;
```

```
    ctrl->cmp_const=0.9;
```

```
    ctrl->thresh_const=0.6;
```

```
    ctrl->quant_const=8.0;
```

```
    ctrl->fps=30.0;
```

```
    ctrl->bitrate=1;
```

```
    for(i=0;i<5;i++) {
```

```
        double    defaults[5]={1.0,0.32,0.16,0.16,0.16};
```

```
        ctrl->base_factors[i]=defaults[i];
```

```
    }
```

```
    ctrl->diag_factor=1.4142136;
```

```
    ctrl->chrome_factor=2.0;
```

```
    strcpy(ctrl->src_name,name);
```

```
    strcpy(ctrl->name,name);
```

- 219 -

```

        strcpy(ctrl->stats_name,name);
        strcpy(ctrl->bin_name,name);
        return(ctrl);
    }

/*  Function Name:      Compress
 *   Description:  X Interface to CompressCtrl
 */

#define      COMP_ICONS      25
#define      VID_ICONS  15

void  Compress(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    Video video=(Video)closure;
    CompCtrl ctrl=InitCompCtrl(video->name);
    int    i, space=video->trans.wavelet.space[0]+1;
    NumInput  num_inputs=(NumInput)MALLOC(2*sizeof(NumInputRec));
    FloatInput flt_inputs=(FloatInput)MALLOC(6*sizeof(FloatInputRec)),

oct_inputs=(FloatInput)MALLOC(space*sizeof(FloatInputRec));
    Message    msg=NewMessage(ctrl->name,NAME_LEN),
               msg_bin=NewMessage(ctrl->bin_name,NAME_LEN),
               msg_stats=NewMessage(ctrl->stats_name,NAME_LEN);
    XtCallbackRec  destroy_call[]={
        {Free,(caddr_t)ctrl},
        {Free,(caddr_t)num_inputs},
        {Free,(caddr_t)flt_inputs},

```

- 220 -

```

        {Free,(caddr_t)oct_inputs},
        {CloseMessage,(caddr_t)msg},
        {CloseMessage,(caddr_t)msg_bin},
        {CloseMessage,(caddr_t)msg_stats},
        {NULL,NULL},
    };

    Widget      parent=FindWidget("frm_compress",XtParent(w)),
               shell=ShellWidget("klics",parent,SW_below,NULL,destroy_call),
               form=FormatWidget("klics_form",shell),

    dec_shell=ShellWidget("klics_cng_dec",shell,SW_menu,NULL,NULL), dec_widgets[3],

    filt_shell=ShellWidget("klics_cng_filt",shell,SW_menu,NULL,NULL), filt_widgets[2],
               widgets[COMP_ICONS], vid_widgets[VID_ICONS],
    oct_widgets[space*2];

    FormItem    items[]={
        {"klics_cancel","cancel",0,0,FW_icon,NULL},
        {"klics_confirm","confirm",1,0,FW_icon,NULL},
        {"klics_title","Compress a video",2,0,FW_label,NULL},
        {"klics_vid_lab","Video Name:",0,3,FW_label,NULL},
        {"klics_vid","NULL",4,3,FW_text,(String)msg},

        {"klics_stats_lab","Statistics:",0,4,FW_label,NULL},
        {"klics_stats","NULL",4,4,FW_yn,(String)&ctrl->stats_switch},
        {"klics_stats_name","NULL",7,4,FW_text,(String)msg_stats},
        {"klics_bin_lab","KLICS File:",0,6,FW_label,NULL},
        {"klics_bin","NULL",4,6,FW_yn,(String)&ctrl->bin_switch},

        {"klics_bin_name","NULL",10,6,FW_text,(String)msg_bin},
        {"klics_dec_lab","Decision:",0,9,FW_label,NULL},
        {"klics_dec_btn","SigmaAbs",4,9,FW_button,"klics_cng_dec"},
        {"klics_qn_float","NULL",0,12,FW_float,(String)&flt_inputs[0]},
    }

```

- 221 -

```

{"klics_qn_scroll",NULL,4,12,FW_scroll,(String)&flt_inputs[0]},

{"klics_th_float",NULL,0,14,FW_float,(String)&flt_inputs[1]},
{"klics_th_scroll",NULL,4,14,FW_scroll,(String)&flt_inputs[1]},
{"klics_cm_float",NULL,0,16,FW_float,(String)&flt_inputs[2]},
{"klics_cm_scroll",NULL,4,16,FW_scroll,(String)&flt_inputs[2]},
{"klics_ch_float",NULL,0,18,FW_float,(String)&flt_inputs[3]},

{"klics_ch_scroll",NULL,4,18,FW_scroll,(String)&flt_inputs[3]},
{"klics_di_float",NULL,0,20,FW_float,(String)&flt_inputs[4]},
{"klics_di_scroll",NULL,4,20,FW_scroll,(String)&flt_inputs[4]},
{"klics_oct_form",NULL,0,22,FW_form,NULL},
{"klics_vid_form",NULL,0,24,FW_form,NULL},
}, vid_items[]={
    {"klics_ic_lab","Image Comp:",0,0,FW_label,NULL},
    {"klics_ic",NULL,1,0,FW_yn,(String)&ctrl->stillvid},
    {"klics_tg_float",NULL,0,1,FW_float,(String)&flt_inputs[5]},
    {"klics_tg_scroll",NULL,1,1,FW_scroll,(String)&flt_inputs[5]},
    {"klics_px_int",NULL,0,3,FW_integer,(String)&num_inputs[0]},

    {"klics_px_down",NULL,1,3,FW_down,(String)&num_inputs[0]},
    {"klics_px_up",NULL,6,3,FW_up,(String)&num_inputs[0]},
    {"klics_auto_lab","Auto Quant:",0,5,FW_label,NULL},
    {"klics_auto",NULL,1,5,FW_yn,(String)&ctrl->auto_q},
    {"klics_buf_lab","Buffer:",0,8,FW_label,NULL},

    {"klics_buf",NULL,1,8,FW_yn,(String)&ctrl->buf_switch},
    {"klics_buf_btn","None",11,8,FW_button,"klics_cng_filt"},
    {"klics_hs_int",NULL,0,10,FW_integer,(String)&num_inputs[1]},
    {"klics_hs_down",NULL,1,10,FW_down,(String)&num_inputs[1]},
    {"klics_hs_up",NULL,14,10,FW_up,(String)&num_inputs[1]},
}, oct_items[2*space];

```

- 222 -

```

MenuItem    dec_menu[]={
    {"klics_dec_max",smeBSBObjectClass,"Maximum",NULL},
    {"klics_dec_abs",smeBSBObjectClass,"SigmaAbs",NULL},
    {"klics_dec_sqr",smeBSBObjectClass,"SigmaSqr",NULL},
}, filt_menu[]={
    {"klics_filt_none",smeBSBObjectClass,"None",NULL},
    {"klics_filt_exp",smeBSBObjectClass,"Exp",NULL},
};

XtCallbackRec    callbacks[]={
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {CompressCtrl,(caddr_t)ctrl},
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {ChangeYN,(caddr_t)&ctrl->stats_switch}, {NULL,NULL},
    {ChangeYN,(caddr_t)&ctrl->bin_switch}, {NULL,NULL},
    {FloatIncDec,(caddr_t)&flt_inputs[0]}, {NULL,NULL},
    {FloatIncDec,(caddr_t)&flt_inputs[1]}, {NULL,NULL},
    {FloatIncDec,(caddr_t)&flt_inputs[2]}, {NULL,NULL},
    {FloatIncDec,(caddr_t)&flt_inputs[3]}, {NULL,NULL},
    {FloatIncDec,(caddr_t)&flt_inputs[4]}, {NULL,NULL},
}, vid_call[]={
    {ChangeYN,(caddr_t)&ctrl->stillvid}, {NULL,NULL},
    {FloatIncDec,(caddr_t)&flt_inputs[5]}, {NULL,NULL},
    {NumIncDec,(caddr_t)&num_inputs[0]}, {NULL,NULL},
    {NumIncDec,(caddr_t)&num_inputs[0]}, {NULL,NULL},
    {ChangeYN,(caddr_t)&ctrl->auto_q}, {NULL,NULL},
    {ChangeYN,(caddr_t)&ctrl->buf_switch}, {NULL,NULL},
    {NumIncDec,(caddr_t)&num_inputs[1]}, {NULL,NULL},
    {NumIncDec,(caddr_t)&num_inputs[1]}, {NULL,NULL},
}, dec_call[]={
    {SimpleMenu,(caddr_t)&ctrl->decide}, {NULL,NULL},

```

- 223 -

```
        {SimpleMenu,(caddr_t)&ctrl->decide}, {NULL,NULL},
        {SimpleMenu,(caddr_t)&ctrl->decide}, {NULL,NULL},
    }, filt_call[]={
        {SimpleMenu,(caddr_t)&ctrl->filter}, {NULL,NULL},
        {SimpleMenu,(caddr_t)&ctrl->filter}, {NULL,NULL},
    }, oct_call[2*space];
XFontStruct *font;
Arg  args[1];

msg->rows=1; msg->cols=NAME_LEN;
msg_stats->rows=1; msg_stats->cols=NAME_LEN;
msg_bin->rows=1; msg_bin->cols=NAME_LEN;
ctrl->src=(Video)closure;

flt_inputs[0].format="Quant: %4.1f";
flt_inputs[0].max=10;
flt_inputs[0].min=0;
flt_inputs[0].value = &ctrl->quant_const;

flt_inputs[1].format="Thresh: %4.1f";
flt_inputs[1].max=10;
flt_inputs[1].min=0;
flt_inputs[1].value = &ctrl->thresh_const;

flt_inputs[2].format="Comp: %4.1f";
flt_inputs[2].max=10;
flt_inputs[2].min=0;
flt_inputs[2].value = &ctrl->cmp_const;

flt_inputs[3].format="Chrome: %4.1f";
flt_inputs[3].max=5;
flt_inputs[3].min=1;
```

- 224 -

```
flt_inputs[3].value = &ctrl->chrome_factor;
```

```
flt_inputs[4].format = "Diag: %4.1f";
```

```
flt_inputs[4].max = 2.0;
```

```
flt_inputs[4].min = 1.0;
```

```
flt_inputs[4].value = &ctrl->diag_factor;
```

```
flt_inputs[5].format = "Target: %4.1f";
```

```
flt_inputs[5].max = 30.0;
```

```
flt_inputs[5].min = 10.0;
```

```
flt_inputs[5].value = &ctrl->fps;
```

```
num_inputs[0].format = "px64k: %1d";
```

```
num_inputs[0].max = 8;
```

```
num_inputs[0].min = 1;
```

```
num_inputs[0].value = &ctrl->bitrate;
```

```
num_inputs[1].format = "History: %1d";
```

```
num_inputs[1].max = 8;
```

```
num_inputs[1].min = 1;
```

```
num_inputs[1].value = &ctrl->feedback;
```

```
for(i=0; i < space; i++) {
```

```
    String format = (char *)MALLOC(20);
```

```
    if (i == 0) sprintf(format, "Octave LPF: %4.2f");
```

```
    else sprintf(format, "Octave %3d: %4.2f", space-i-1);
```

```
    oct_inputs[i].format = format;
```

```
    oct_inputs[i].max = 1.0;
```

```
    oct_inputs[i].min = 0.0;
```

```
    oct_inputs[i].value = &ctrl->base_factors[space-i-1];
```

```
    oct_items[2*i].name = "klics_oct_float";
```



- 225 -

```

oct_items[2*i].contents=NULL;
oct_items[2*i].fromHoriz=0;
oct_items[2*i].fromVert=i==0?0:2*i-1;
oct_items[2*i].type=FW_float;
oct_items[2*i].hook=(String)&oct_inputs[i];
oct_items[2*i+1].name="klics_oct_scroll";
oct_items[2*i+1].contents=NULL;
oct_items[2*i+1].fromHoriz=1;
oct_items[2*i+1].fromVert=i==0?0:2*i-1;
oct_items[2*i+1].type=FW_scroll;
oct_items[2*i+1].hook=(String)&oct_inputs[i];
oct_call[2*i].callback=FloatIncDec;
oct_call[2*i].closure=(String)&oct_inputs[i];
oct_call[2*i+1].callback=NULL;
oct_call[2*i+1].closure=NULL;

```

```

}

```

```

FillForm(form,COMP_ICONS-(video->size[2]>1?0:1),items,widgets,callbacks);
FillForm(widgets[23],2*space,oct_items,oct_widgets,oct_call);
FillMenu(dec_shell,THREE,dec_menu,dec_widgets,dec_call);
font=FindFont(widgets[12]);

```

```

XtSetArg(args[0],XtNwidth,2+TextWidth(0,"Maximum\nSigmaAbs\nSigmaSqr",font));

```

```

XtSetValues(widgets[12],args,ONE);

```

```

if (video->size[2]>1) {

```

```

    FillForm(widgets[24],VID_ICONS,vid_items,vid_widgets,vid_call);

```

```

    FillMenu(filt_shell,TWO,filt_menu,filt_widgets,filt_call);

```

```

    font=FindFont(vid_widgets[11]);

```

```

    XtSetArg(args[0],XtNwidth,2+TextWidth(0,"None\nExp",font));

```

```

    XtSetValues(vid_widgets[11],args,ONE);

```

```

}

```

```

XtPopup(shell,XtGrabExclusive);

```

```

}

```

- 226 -

source/KlicsSA.c

/\*

Full still/video Knowles-Lewis Image Compression System utilising HVS  
properties  
and delta-tree coding

Stand-Alone version uses fixed image format and static data structures

\*/

#include "KlicsSA.h"

#include <math.h>

extern void Convolve();

/\* useful X definitions \*/

typedef char Boolean;

#define True 1

#define False 0

#define String char\*

/\* token modes (empty) \*/

#define EMPTY 0

#define CHANNEL\_EMPTY 1

#define OCTAVE\_EMPTY 2

#define LPF\_EMPTY 3

#define FULL 4

/\* Function Name: AccessSA

\* Description: Find index address from co-ordinates

\* Arguments: x, y - (x,y) co-ordinates

- 227 -

```

*           oct, sub, channel - octave, sub-band and channel co-ordinates
*   Returns: index into data[channel][index]
*/

int   AccessSA(x,y,oct,sub,channel)

int   x, y, oct, sub, channel;

{

return((((x < < 1)+(sub > > 1)+(SA_WIDTH > > (channel == 0?0:1))*((y < < 1)+(1&sub)
))< < oct);
}

/*   Function Name:   DecideSA
*   Description:   Calculate value representing the difference between new and old
blocks
*   Arguments:   new, old - blocks to compare
*   Returns:   difference value
*/

int   DecideSA(new,old)

Block new, old;

{

int   X, Y, sigma=0;

for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
sigma += abs(new[X][Y]-old[X][Y]);
return(sigma);
}

```

- 228 -

```
/*    Function Name:    DecideDoubleSA
 *    Description:    Calculates normal w.r.t differencing algorithm
 *    Arguments:    norm - normal value
 *    Returns:    new normal value
 */
```

```
double    DecideDoubleSA(norm)
```

```
double    norm;
```

```
{
    return(4.0*norm);
}
```

```
Boolean    DecisionSA(new,old,norm)
```

```
Block new, old;
```

```
double    norm;
```

```
{
    return((double)DecideSA(new,old) <= DecideDoubleSA(norm));
}
```

```
/*    Function Name:    HuffmanSA
 *    Description:    Calculates the number of bits for the Huffman code representing
level
 *    Arguments:    level - level to be encoded
 *    Returns:    number of bits in codeword
 */
```

```
int    HuffmanSA(level)
```

- 229 -

```
int    level;
```

```
{
    return(level == 0?2:(abs(level) < 3?3:1 + abs(level)));
}
```

```
/*    Function Name:    HuffCodeSA
 *    Description:    Generates Huffman code representing level
 *    Arguments:    level - level to be encoded
 *    Returns:    coded bits in char's
 */
```

```
unsigned char *HuffCodeSA(level)
```

```
int    level;
```

```
{
    unsigned char *bytes=(unsigned char *)MALLOC((7+Huffman(level))/8);

    bytes[0]=(abs(level) < 3?abs(level):3) | (level < 0?4:0);
    if (abs(level) > 2) {
        int    index=(7+Huffman(level))/8-1;

        bytes[index]=bytes[index] | (1 < < (Huffman(level)-1)%8);
    }
    return(bytes);
}
```

```
unsigned char *CodeIntSA(number,bits)
```

```
int    number, bits;
```

- 230 -

```

{
    int    len=(7+bits)/8;
    unsigned char *bytes=(unsigned char *)MALLOC(len);
    int    byte;

    for(byte=0;byte<len;byte++) {
        bytes[byte]=0xff&number;
        number=number>>8;
    }
    return(bytes);
}

int    ReadIntSA(bits,bfp)

int    bits;
Bits   bfp;

{
    int    len=(7+bits)/8;
    unsigned char bytes[len];
    int    byte, number=0;

    bread(bytes,bits,bfp);
    for(byte=0;byte<len;byte++)
        number=number|((int)bytes[byte]<<byte*8);
    number=(number<<sizeof(int)*8-bits)>>sizeof(int)*8-bits;
    return(number);
}

/*    Function Name:      HuffReadSA
*    Description:  Read Huffman encoded number from binary file
*    Arguments:    bfp - binary file pointer

```

- 231 -

```

*   Returns:      decoded level
*/

int   HuffReadSA(bfp)

Bits   bfp;

{
    int   value;
    unsigned char   byte;
    Boolean   negative=False;

    bread(&byte,2,bfp);
    value=(int)byte;
    if (byte=='\0') return(0);
    else {
        bread(&byte,1,bfp);
        negative=(byte!='\0');
    }
    if (value<3) return(negif(negative,value));
    for(byte='\0';byte=='\0';value++) bread(&byte,1,bfp);
    return(negif(negative,value-1));
}

/*   Function Name:      QuantizeSA
*   Description:  RM8 style quantizer
*   Arguments:   data - unquantised number
*               q - quantizing divisor
*               level - quantised to level
*   Returns:      quantized data & level
*/

```

- 232 -

```
int    QuantizeSA(data,q,level)
```

```
int    data, q, *level;
```

```
{
```

```
    int    mag_level=abs(data)/q;
```

```
    *level=negif(data<0,mag_level);
```

```
    return(negif(data<0,mag_level*q+(mag_level!=0?(q-1)>>1:0)));
```

```
}
```

```
/*    Function Name:    ProposedSA
```

```
*    Description:    Calculates proposed block values
```

```
*    Arguments:    pro - proposed block
```

```
*                  lev - proposed block quantized levels
```

```
*                  old, new - old and new block values
```

```
*                  norms - HVS normals
```

```
*    Returns:    new==0, proposed values (pro) and levels (lev)
```

```
*/
```

```
Boolean    ProposedSA(pro,lev,old,new,norms)
```

```
Block    pro, lev, old, new;
```

```
double    norms[3];
```

```
{
```

```
    Block    zero_block={{0,0},{0,0}};
```

```
    int    X, Y, step=norms[0]<1.0?1:(int)norms[0];
```

```
    Boolean    zero=DecisionSA(new,zero_block,norms[1]);
```

```
    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
```



- 233 -

```

pro[X][Y]=zero?0:old[X][Y]+Quantize(new[X][Y]-old[X][Y],step,&(lev[X][Y]));
    return(zero);
}

```

```

/*  Function Name:    ZeroCoeffsSA
 *  Description:      Zero out video data
 *  Arguments:        data - image data
 *                    addr - addresses
 *  Returns:           zeros data[addr[][]]
 */

```

```

void ZeroCoeffsSA(data,addr)

```

```

short *data;
Block addr;

```

```

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
        data[addr[X][Y]]=0;
}

```

```

/*  Function Name:    BlockZeroSA
 *  Description:      Test if all block values are zero
 *  Arguments:        block - block under test
 *  Returns:           block==0
 */

```

```

Boolean    BlockZeroSA(block)

```

```

Block block;

```

- 234 -

```

{
    int    X, Y;
    Boolean    zero = True;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
        if (block[X][Y]!=0) zero=False;
    return(zero);
}

/*    Function Name:    SendTokenSA
 *    Description:    Increments token frequency
 *    Arguments:    token - token to be transmitted
 *                  channel, sub, oct - co-ordinates
 *                  bfp - binary file pointer
 *                  empty - zero state {EMPTY | CHANNEL_EMPTY |
OCTAVE_EMPTY | LPF_EMPTY | FULL}
 *                  branch - branch of tree (0-3)
 *    Returns:    encodes token
 */

void    SendTokenSA(token,channel,sub,oct,bfp,empty,branch)

int    token, channel, sub, oct, *empty, branch;
Bits    bfp;

{
    int    full=FULL, i;
    String
token_name[TOKENS]={ "ZERO_STILL", "NON_ZERO_STILL", "BLOCK_SAME", "ZE
RO_VID", "BLOCK_CHANGE",

"LOCAL_ZERO", "LOCAL_NON_ZERO", "CHANNEL_ZERO", "CHANNEL_NON_ZE

```

- 235 -

RO", "OCT\_ZERO", "OCT\_NON\_ZERO",

"LPF\_ZERO", "LPF\_NON\_ZERO", "LPF\_LOC\_ZERO", "LPF\_LOC\_NON\_ZERO"};

switch(\*empty) {

case EMPTY:

if (token!=ZERO\_STILL && token!=BLOCK\_SAME) {

SendTokenSA(LOCAL\_NON\_ZERO,channel,sub,oct,bfp,&full,branch);

for(i=0;i<channel;i++)

SendTokenSA(CHANNEL\_ZERO,i,sub,oct,bfp,&full,branch);

\*empty=CHANNEL\_EMPTY;

SendTokenSA(token,channel,sub,oct,bfp,empty,branch);

}

break;

case CHANNEL\_EMPTY:

if (token!=ZERO\_STILL && token!=BLOCK\_SAME) {

SendTokenSA(CHANNEL\_NON\_ZERO,channel,sub,oct,bfp,&full,branch);

for(i=1;i<sub;i++)

SendTokenSA(token==NON\_ZERO\_STILL?ZERO\_STILL:BLOCK\_SAME,channel,i,oct,bfp,&full,branch);

\*empty=FULL;

SendTokenSA(token,channel,sub,oct,bfp,empty,branch);

}

break;

case OCTAVE\_EMPTY:

if (token!=ZERO\_STILL && token!=BLOCK\_SAME) {

SendTokenSA(OCT\_NON\_ZERO,channel,sub,oct,bfp,&full,branch);

for(i=0;i<branch;i++)

SendTokenSA(token==NON\_ZERO\_STILL?ZERO\_STILL:BLOCK\_SAME,channel,sub

- 236 -

```

,oct,bfp,&full,branch);
        *empty=FULL;
        SendTokenSA(token,channel,sub,oct,bfp,empty,branch);
    }
    break;
case LPF_EMPTY:
    if (token!=LPF_ZERO) {

SendTokenSA(LPF_LOC_NON_ZERO,channel,sub,oct,bfp,&full,branch);
        for(i=0;i<channel;i++)
SendTokenSA(LPF_ZERO,i,sub,oct,bfp,&full,branch);
        *empty=FULL;
        SendTokenSA(token,channel,sub,oct,bfp,empty,branch);
    }
    break;
case FULL:
    Dprintf("%s\n",token_name[token]);
    bwrite(&token_codes[token],token_bits[token],bfp);
    break;
}
}

```

```

/*  Function Name:    ReadBlockSA
*
*  Description:    Read block from video
*
*  Arguments:    new, old, addr - new and old blocks and addresses
*
*                  x, y, oct, sub, channel - co-ordinates of block
*
*                  src, dst - frame data
*
*  Returns:    block values
*/

```

```

void  ReadBlockSA(new,old,addr,x,y,oct,sub,channel,src,dst)

```

- 237 -

```

Block new, old, addr;
int    x, y, oct, sub, channel;
short  *src[3], *dst[3];

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
        addr[X][Y]=AccessSA((x<<1)+X,(y<<1)+Y,oct,sub,channel);
        new[X][Y]=(int)src[channel][addr[X][Y]];
        old[X][Y]=(int)dst[channel][addr[X][Y]];
    }
}

/*  Function Name:      CalcNormalsSA
 *  Description:  Calculates HVS weighted normals
 *  Arguments:   oct, sub, channel - co-ordinates
 *              norms - pre-initialised normals
 *  Returns:     weighted normals
 */

void  CalcNormalsSA(oct,sub,channel,norms,quant_const)

int    oct, sub, channel;
double    norms[3], quant_const;

{
    int    norm, base_oct=oct+(channel!=0?1:0)+(sub==0?1:0);

    for(norm=0;norm<3;norm++) {
        if (norm!=0) norms[norm] *= quant_const;
        norms[norm] *= base_factors[base_oct]*(sub==3?diag_factor:1.0);
    }
}

```

- 238 -

```

        if (channel!=0) norms[norm] *= chrome_factor;
        norms[norm] *=(double)(1 << SA_PRECISION);
    }
}

/*  Function Name:      MakeDecisions2SA
 *  Description:  Decide on new compression mode from block values
 *  Arguments:   old, new, pro - block values
 *
 *              zero - zero flag for new block
 *              norms - HVS normals
 *              mode - current compression mode
 *              decide - comparison algorithm
 *  Returns:     new compression mode
 */

int  MakeDecisions2SA(old,new,pro,lev,zero,norms,mode)

Block  new, old, pro, lev;
Boolean  zero;
double  norms[3];
int  mode;

{
    Block  zero_block={{0,0},{0,0}};
    int  new_mode=mode==STILL || BlockZeroSA(old)?STILL:SEND,
        np=DecideSA(new,pro), no=DecideSA(new,old);

    if (new_mode==STILL) new_mode=np>=no || zero ||
BlockZeroSA(lev)?STOP:STILL;
    else new_mode=zero && np<no?VOID:np>=no ||
DecisionSA(new,old,norms[2]) || BlockZeroSA(lev)?STOP:SEND;
    return(new_mode);
}

```

- 239 -

}

```

/*      Function Name:      UpdateCoeffsSA
 *      Description:  Encode proposed values and write data
 *      Arguments:   pro, lev, addr - proposed block, levels and addresses
 *                  channel, oct - co-ordinates
 *                  dst - destination data
 *                  bfp - binary file pointer
 *      Returns:      alters dst[channel][addr[][]]
 */

```

```
void  UpdateCoeffsSA(pro,lev,addr,channel,oct,dst,bfp)
```

```
Block  pro, lev, addr;
```

```
int    channel, oct;
```

```
short  *dst[3];
```

```
Bits   bfp;
```

```
{
```

```
    int    X, Y;
```

```
    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
```

```
        int    bits=HuffmanSA(lev[X][Y]),
```

```
            level=abs(lev[X][Y]);
```

```
        unsigned char    *bytes=HuffCodeSA(lev[X][Y]);
```

```
        dst[channel][addr[X][Y]]=(short)pro[X][Y];
```

```
        bwrite(bytes,bits,bfp);
```

```
        XtFree(bytes);
```

```
    }
```

```
}
```

- 240 -

```

/*  Function Name:      SendTreeSA
 *   Description:      Encode tree blocks
 *   Arguments:      prev_mode - compression mode
 *                   x, y, oct, sub, channel - co-ordinates
 *                   empty - token mode
 *                   branch - tree branch number
 *   Returns:      active block indicator
 */

```

Boolean

SendTreeSA(prev\_mode,x,y,oct,sub,channel,src,dst,empty,branch,quant\_const,bfp)

```

int    prev_mode, x, y, oct, sub, channel, *empty, branch;
short  *src[3], *dst[3];
double    quant_const;
Bits    bfp;

{
    Block  addr, old, new, pro, lev;
    int    new_mode, X, Y;
    double    norms[3]={quant_const.thresh_const.cmp_const}; /* quant. thresh.
compare */
    Boolean    active=False;

    ReadBlockSA(new,old,addr,x,y,oct,sub,channel,src,dst);
    if (prev_mode!=VOID) {
        Boolean    zero;

        CalcNormalsSA(oct,sub,channel,norms,quant_const);
        zero=ProposedSA(pro,lev,old,new,norms);
        new_mode=MakeDecisions2SA(old,new,pro,lev,zero,norms,prev_mode);
        switch(new_mode) {

```



- 241 -

```

    case STOP:
        SendTokenSA(prev_mode == STILL ||
BlockZeroSA(old)?ZERO_STILL:BLOCK_SAME,channel,sub,oct,bfp,empty,branch);
        break;
    case STILL:
    case SEND:
        active = True;
        SendTokenSA(prev_mode == STILL ||
BlockZero(old)?NON_ZERO_STILL:BLOCK_CHANGE,channel,sub,oct,bfp,empty,branch);

        UpdateCoeffsSA(pro,lev,addr,channel,oct,dst,bfp);
        break;
    case VOID:
        SendTokenSA(ZERO_VID,channel,sub,oct,bfp,empty,branch);
        ZeroCoeffsSA(dst[channel],addr);
        break;
    }
} else {
    if (BlockZeroSA(old)) new_mode = STOP;
    else {
        ZeroCoeffsSA(dst[channel],addr);
        new_mode = VOID;
    }
}

if (oct > 0 && new_mode != STOP) {
    int    mt = OCTAVE_EMPTY, full = FULL;

    Dprintf("x = %d, y = %d, oct = %d sub = %d mode
%d\n",x,y,oct,sub,new_mode);

    for(Y=0; Y<2; Y++) for(X=0; X<2; X++)

(void)SendTreeSA(new_mode.x*2+X,y*2+Y,oct-1,sub,channel.src,dst,&mt,X+2*Y,qua

```

- 242 -

```

nt_const.bfp);
        if (mt==OCTAVE_EMPTY && new_mode!=VOID)
SendTokenSA(OCT_ZERO,channel.sub.oct,bfp,&full,0);
    }
    return(active);
}

```

```

/*  Function Name:    SendLPF_SA
 *  Description:    Encode LPF sub-band
 *  Arguments:    mode - compression mode
 *  Returns:    encodes data
 */

```

```

void  SendLPF_SA(mode,src,dst,bfp,quant_const)

```

```

int    mode;
short  *src[3], *dst[3];
Bits   bfp;
double      quant_const;

```

```

{
    Block new, old, pro, lev, addr;
    int    channel, channels=3, x, y, full=FULL,
          octs_lum=3,

size[2]={SA_WIDTH>>octs_lum+1,SA_HEIGHT>>octs_lum+1};

```

```

    for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {
        int    empty=LPF_EMPTY;

```

```

    for(channel=0;channel<channels;channel++) {
        int    octs=channel!=0?2:3.

```

- 243 -

```

        new_mode, X, Y, step, value, bits=0;
double    norms[3]={quant_const,thresh_const,cmp_const};

CalcNormalsSA(octs-1,0,channel,norms,quant_const);
step=norms[0] < 1.0?1:(int)norms[0];
for(bits=0, value=((1 < < 8+SA_PRECISION)-1)/step;value!=0;bits++)
    value=value > > 1;
ReadBlockSA(new,old,addr,x,y,octs-1,0,channel,src,dst);

/* Proposed */
for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)

pro[X][Y]=old[X][Y]+QuantizeSA(new[X][Y]-old[X][Y],step,&(lev[X][Y]));

/* MakeDecisions */
new_mode=mode==STILL?STILL:DecisionSA(new,old,norms[2]) ||
BlockZeroSA(lev)?STOP:SEND;

switch(new_mode) {
case SEND:
    SendTokenSA(LPF_NON_ZERO,channel,0,octs,bfp,&empty,0);
    UpdateCoeffsSA(pro,lev,addr,channel,octs,dst,bfp);
    break;
case STILL:
    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
        unsigned char *bytes=CodeIntSA(lev[X][Y],bits);

        dst[channel][addr[X][Y]]=(short)pro[X][Y];
        bwrite(bytes,bits,bfp);
        XtFree(bytes);
    }
    break;

```

- 244 -

```

        case STOP:
            SendTokenSA(LPF_ZERO,channel,0,octs,bfp,&empty,0);
            break;
        }
    }
    if (mode!=STILL && empty == LPF_EMPTY)
SendTokenSA(LPF_LOC_ZERO,channel,0,octs_lum,bfp,&full,0);
    }
}

```

```

/*  Function Name:    CompressFrameSA
 *  Description:    Compress a Frame
 *  Arguments:    mode - compression mode STILL or SEND
 *                src, dst - source and destination data
 *                bfp - binary file pointer for result
 *                quant_const - quantization parameter
 */

```

```
void  CompressFrameSA(mode,src,dst,bfp,quant_const)
```

```
int    mode;
```

```
short  *src[3], *dst[3];
```

```
Bits    bfp;
```

```
double    quant_const;
```

```
{
```

```
    int    sub, channel, x, y, i,
```

```
           octs_lum=3,
```

```
size[2]={SA_WIDTH>>1+octs_lum,SA_HEIGHT>>1+octs_lum};
```

```
for(channel=0;channel<3;channel++) {
```

- 245 -

```

    int
    frame_size[2]={SA_WIDTH>>(channel==0?0:1),SA_HEIGHT>>(channel==0?0:1
    )},

    frame_area=frame_size[0]*frame_size[1];

    for(i=0;i<frame_area;i++)
    src[channel][i]=src[channel][i]<<SA_PRECISION;
    Convolve(src[channel],False,frame_size,0,channel==0?3:2);
}
bwrite((char *)&quant_const,sizeof(double)*8,bfp);
SendLPF_SA(mode,src,dst,bfp,quant_const);
for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {
    int    empty=EMPTY, full=FULL;

    for(channel=0;channel<3;channel++) {
        int    octs=channel!=0?2:3;

        for(sub=1;sub<4;sub++)
        (void)SendTreeSA(mode,x,y,octs-1,sub,channel,src,dst,&empty,0,quant_const,bfp);
        switch(empty) {
            case FULL:
                empty=CHANNEL_EMPTY;
                break;
            case CHANNEL_EMPTY:
SendTokenSA(CHANNEL_ZERO,channel,sub,octs-1,bfp,&full,0);
                break;
        }
    }
}
if (empty==EMPTY)
SendTokenSA(LOCAL_ZERO,channel,sub,octs_lum-1,bfp,&full,0);
}
}

```

- 246 -

source/KlicsTestSA.c

```
#include    "xwave.h"
#include    "KlicsSA.h"
```

```
extern void  CompressFrameSA();
```

```
typedef      struct {
    Video src;
    char  bin_name[STRLEN];
    Boolean  stillvid;
    double  quant_const;
} KlicsCtrlRec, *KlicsCtrl;
```

```
/*    Function Name:    KlicsCtrlSA
 *    Description:    Test harness for KlicsSA in xwave
 *    Arguments:        w - Xaw widget
 *                        closure - compression control record
 *                        call_data - NULL
 *    Returns:        send data to binary file
 */
```

```
void  KlicsCtrlSA(w,closure.call_data)
```

```
Widget      w;
caddr_t      closure, call_data;
```

```
{
    KlicsCtrl  ctrl=(KlicsCtrl)closure;
    int  sizeY=SA_WIDTH*SA_HEIGHT,
```

- 247 -

```

        sizeUV=SA_WIDTH*SA_HEIGHT/4, i, z;
short  *dst[3]={
    (short *)MALLOC(sizeof(short)*sizeY),
    (short *)MALLOC(sizeof(short)*sizeUV),
    (short *)MALLOC(sizeof(short)*sizeUV),
}, *src[3]={
    (short *)MALLOC(sizeof(short)*sizeY),
    (short *)MALLOC(sizeof(short)*sizeUV),
    (short *)MALLOC(sizeof(short)*sizeUV),
};

char  file_name[STRLEN];
Bits  bfp;
Boolean  true=True, false=False;

for(i=0;i<sizeY;i++) dst[0][i]=0;
for(i=0;i<sizeUV;i++) { dst[1][i]=0; dst[2][i]=0; }

sprintf(file_name,"%s%s/%s%s\0",global->home,KLICS_SA_DIR,ctrl->bin_name,KLI
CS_SA_EXT);
bfp=bopen(file_name,"w");
bwrite(&ctrl->stillvid,1,bfp);
bwrite(&ctrl->src->size[2],sizeof(int)*8,bfp);
for(z=0;z<ctrl->src->size[2];z++) {
    GetFrame(ctrl->src,z);
    for(i=0;i<sizeY;i++) src[0][i]=ctrl->src->data[0][z][i];
    for(i=0;i<sizeUV;i++) {
        src[1][i]=ctrl->src->data[1][z][i];
        src[2][i]=ctrl->src->data[2][z][i];
    }
    CompressFrameSA(z==0 ||

```

- 248 -

```
ctrl->stillvid?STILL:SEND,src,dst,bfp,ctrl->quant_const);
```

```
    FreeFrame(ctrl->src,z);
```

```
    }
```

```
    bflush(bfp);
```

```
    bclose(bfp);
```

```
    XtFree(dst[0]);
```

```
    XtFree(dst[1]);
```

```
    XtFree(dst[2]);
```

```
    XtFree(src[0]);
```

```
    XtFree(src[1]);
```

```
    XtFree(src[2]);
```

```
}
```

```
KlicsCtrl    InitKlicsCtrl(name)
```

```
String name;
```

```
{
```

```
    KlicsCtrl    ctrl=(KlicsCtrl)MALLOC(sizeof(KlicsCtrlRec));
```

```
    ctrl->stillvid=True;
```

```
    ctrl->quant_const=8.0;
```

```
    strcpy(ctrl->bin_name,name);
```

```
    return(ctrl);
```

```
}
```

```
#define    KLICS_SA_ICONS 8
```

```
#define KLICS_SA_VID_ICONS 2
```

```
void    KlicsSA(w,closure,call_data)
```

```
Widget    w;
```



- 249 -

```

caddr_t      closure, call_data;

{
    Video video=(Video)closure;
    KlicsCtrl  ctrl=InitKlicsCtrl(video->name);
    FloatInput flt_inputs=(FloatInput)MALLOC(sizeof(FloatInputRec));
    Message    msg_bin=NewMessage(ctrl->bin_name,NAME_LEN);
    XtCallbackRec  destroy_call[]={
        {Free,(caddr_t)ctrl},
        {Free,(caddr_t)flt_inputs},
        {CloseMessage,(caddr_t)msg_bin},
        {NULL,NULL},
    };
    Widget      parent=FindWidget("frm_compress",XtParent(w)),

shell=ShellWidget("klicsSA",parent,SW_below,NULL,destroy_call),
        form=FormatWidget("klicsSA_form",shell),
        widgets[KLICS_SA_ICONS],
vid_widgets[KLICS_SA_VID_ICONS];
    FormItem    items[]={
        {"klicsSA_cancel","cancel",0,0,FW_icon,NULL},
        {"klicsSA_confirm","confirm",1,0,FW_icon,NULL},
        {"klicsSA_title","Run Klics SA",2,0,FW_label,NULL},
        {"klicsSA_bin_lab","KLICS File:",0,3,FW_label,NULL},
        {"klicsSA_bin_name",NULL,4,3,FW_text,(String)msg_bin},

        {"klicsSA_qn_float",NULL,0,5,FW_float,(String)&flt_inputs[0]},
        {"klicsSA_qn_scroll",NULL,6,5,FW_scroll,(String)&flt_inputs[0]},
        {"klicsSA_vid_form",NULL,0,7,FW_form,NULL},
    }, vid_items[]={
        {"klicsSA_ic_lab","Image Comp:",0,0,FW_label,NULL},
        {"klicsSA_ic",NULL,1,0,FW_yn,(String)&ctrl->stillvid},
    };
};

```

- 250 -

```

XtCallbackRec    callbacks[]={
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {KlicsCtrlSA,(caddr_t)ctrl},
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {FloatIncDec,(caddr_t)&flt_inputs[0]}, {NULL,NULL},
}, vid_call[]={
    {ChangeYN,(caddr_t)&ctrl->stillvid}, {NULL,NULL},
};

ctrl->src=video;
msg_bin->rows=1; msg_bin->cols=NAME_LEN;

flt_inputs[0].format="Quant: %4.1f";
flt_inputs[0].max=10;
flt_inputs[0].min=0;
flt_inputs[0].value= &ctrl->quant_const;

FillForm(form.KLICS_SA_ICONS-(video->size[2]>1?0:1),items,widgets,callbacks);
    if (video->size[2]>1)

FillForm(widgets[7],KLICS_SA_VID_ICONS,vid_items,vid_widgets,vid_call);
    XtPopup(shell,XtGrabExclusive);
}

```

- 251 -

## source/Malloc.c

```
/*  
    Memory allocation routine  
*/  
  
#include    <stdio.h>  
  
char  *MALLOC(size)  
  
int    size;  
  
{  
    char *ptr=(char *)calloc(1,size);  
  
    if (ptr==NULL) Eprintf("Unable to allocate %d bytes of memory\n",size);  
    return(ptr);  
}
```

- 252 -

## source/Menu.c

```
/*
 *   Pull-Right Menu functions
 */

#include    <stdio.h>
#include    <X11/IntrinsicP.h>
#include    <X11/StringDefs.h>

#include    <X11/Xaw/XawInit.h>
#include    <X11/Xaw/SimpleMenP.h>
#include    <X11/Xaw/CommandP.h>

static void prPopupMenu();
static void NotifyImage();
static void PrLeave();

void InitActions(app_con)

XtAppContext    app_con:

{
    static XtActionsRec    actions[] = {
        {"prPopupMenu",prPopupMenu},
        {"notifyImage",NotifyImage},
        {"prLeave",PrLeave},
    };

    XtAppAddActions(app_con.actions,XtNumber(actions));
```

- 253 -

}

```
static void prPopupMenu(w,event,params,num_params)
```

```
Widget w;
```

```
XEvent * event;
```

```
String * params;
```

```
Cardinal * num_params;
```

{

```
Widget menu, temp;
```

```
Arg arglist[2];
```

```
Cardinal num_args;
```

```
int menu_x, menu_y, menu_width, menu_height, button_width, button_height;
```

```
Position button_x, button_y;
```

```
if (*num_params!=1) {
```

```
    char error_buf[BUFSIZ];
```

```
    sprintf(error_buf, "prPopupMenu: %s.", "Illegal number of translation  
arguments");
```

```
    XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
```

```
    return;
```

}

```
temp = w;
```

```
while(temp != NULL) {
```

```
    menu = XtNameToWidget(temp, params[0]);
```

```
    if (menu == NULL)
```

```
        temp = XtParent(temp);
```

```
    else
```

```
        break;
```

}

- 254 -

```
if (menu == NULL) {
    char error_buf[BUFSIZ];
    sprintf(error_buf, "prPopupMenu: %s %s.",
        "Could not find menu widget named", params[0]);
    XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
    return;
}
if (!XtIsRealized(menu))
    XtRealizeWidget(menu);

menu_width = menu->core.width + 2 * menu->core.border_width;
button_width = w->core.width + 2 * w->core.border_width;
button_height = w->core.height + 2 * w->core.border_width;

menu_height = menu->core.height + 2 * menu->core.border_width;

XtTranslateCoords(w, 0, 0, &button_x, &button_y);
menu_x = button_x;
menu_y = button_y + button_height;

if (menu_x < 0)
    menu_x = 0;
else {
    int scr_width = WidthOfScreen(XtScreen(menu));
    if (menu_x + menu_width > scr_width)
        menu_x = scr_width - menu_width;
}

if (menu_y < 0)
    menu_y = 0;
else {
    int scr_height = HeightOfScreen(XtScreen(menu));
```

- 255 -

```

    if (menu_y + menu_height > scr_height)
        menu_y = scr_height - menu_height;
}

```

```

num_args = 0;

```

```

XtSetArg(arglist[num_args], XtNx, menu_x); num_args++;

```

```

XtSetArg(arglist[num_args], XtNy, menu_y); num_args++;

```

```

XtSetValues(menu, arglist, num_args);

```

```

XtPopupSpringLoaded(menu);

```

```

}

```

```

/*

```

```

static void

```

```

prRealize(w, mask, attrs)

```

```

Widget w;

```

```

Mask *mask;

```

```

XSetWindowAttributes *attrs;

```

```

{

```

```

    (*superclass->core_class.realize) (w, mask, attrs);

```

```

*/

```

```

    /* We have a window now. Register a grab. */

```

```

/*

```

```

    XGrabButton( XtDisplay(w), AnyButton, AnyModifier, XtWindow(w),

```

```

                TRUE, ButtonPressMask|ButtonReleaseMask,

```

```

                GrabModeAsync, GrabModeAsync, None, None );

```

```

}

```

```

*/

```

```

static void NotifyImage(w,event,params,num_params)

```

```

Widget      w;

```

```

XEvent      *event;

```

- 256 -

String \*params;

Cardinal \*num\_params;

{

CommandWidget cbw=(CommandWidget)w;

if (cbw->command.set) XtCallCallbackList(w,cbw->command.callbacks,event);

}

static void PrLeave(w,event,params,num\_params)

Widget w;

XEvent \*event;

String \*params;

Cardinal \*num\_params;

{

SimpleMenuWidget smw=(SimpleMenuWidget)w;

Dprintf("PrLeave\n");

}



- 257 -

## source/Message.c

```
/*
 *   Message I/O Utility Routines
 */

#include    "../include/xwave.h"
#include    <varargs.h>

#define     MESS_ICONS      3

void  TextSize(msg)

Message    msg;

{
    int     i=-1, max_len=0;
    char    *text=msg->info.ptr;

    msg->rows=0;
    msg->cols=0;
    do {
        i++;
        if (text[i]=='\n' || text[i]=='\0') {
            if (msg->cols>max_len) max_len=msg->cols;
            msg->cols=0;
            msg->rows++;
        } else msg->cols++;
    } while (text[i]!='\0');
    if (i>0) if (text[i-1]=='\n') msg->rows--;
```

- 258 -

```

    msg->cols=max_len;
}

Message      NewMessage(text,size)

char    *text;
int     size;

{
    Message      msg=(Message)MALLOC(sizeof(MessageRec));

    msg->shell=NULL;
    msg->widget=NULL;
    msg->info.firstPos=0;
    if (!(msg->own_text=text==NULL)) msg->info.ptr=text;
    else {
        msg->info.ptr=(char *)MALLOC(size+1);
        msg->info.ptr[0]='\0';
    }
    msg->info.format=FMT8BIT;
    msg->info.length=0;
    msg->rows=0;
    msg->cols=0;
    msg->size=size;
    msg->edit=XawtextEdit;
    return(msg);
}

void      CloseMessage(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data:

```

- 259 -

```

{
    Message      msg=(Message)closure;

    Destroy(w,(caddr_t)msg->shell.NULL);
    if (msg->own_text) XtFree(msg->info.ptr);
    XtFree(msg);
}

```

```

void  MessageWindow(parent,msg,title,close,call)

```

```

Widget      parent;
Message      msg;
char  *title;
Boolean      close;
XtCallbackRec  call[];

{
    Widget      form, widgets[MESS_ICONS]={NULL,NULL,NULL};
    FormItem     items[]={
        {"msg_cancel","cancel",0,0,FW_icon,NULL},
        {"msg_label",title,1,0,FW_label,NULL},
        {"msg_msg",NULL,0,2,FW_text,(String)msg},
    };

    msg->edit=XawtextRead;

    msg->shell=ShellWidget("msg",parent,parent==global->toplevel?SW_top:SW_below,
    NULL.NULL);

    form=FormatWidget("msg_form",msg->shell);

    FillForm(form.MESS_ICONS-(close?0:1),&items[close?0:1],&widgets[close?0:1],call);
    XtPopup(msg->shell,XtGrabNone);
}

```

- 260 -

```

    Mflush(msg);
}

void Mflush(msg)

Message    msg;

{
    if (global->batch == NULL && msg->widget != NULL) {
        Display    *dpy = XtDisplay(global->toplevel);
        int    i, lines=0;
        Arg    args[1];

        for(i=msg->info.length-1; lines < msg->rows && i >= 0; i--)
            if (msg->info.ptr[i] == '\n' && i != msg->info.length-1) lines++;
        i++;
        if (msg->info.ptr[i] == '\n') i++;
        strcpy(msg->info.ptr, &msg->info.ptr[i]);
        msg->info.length -= i;
        XtSetArg(args[0], XtNstring, msg->info.ptr);
        XSyncronize(dpy, True);
        XtSetValues(msg->widget, args, ONE);
        XSyncronize(dpy, False);
    }
}

void mprintf(msg, ap)

Message    msg;
va_list    ap;

{

```

- 261 -

```

char    *format;

format=va_arg(ap,char *);
if (global->batch!=NULL) vprintf(format,ap);
else {
    char    text[STRLEN];
    int     i;

    vsprintf(text,format,ap);
    i=strlen(text)+msg->info.length-msg->size;
    if (i>0) {
        strcpy(msg->info.ptr,&msg->info.ptr[i]);
        msg->info.length-=i;
    }
    strcat(msg->info.ptr,text);
    msg->info.length+=strlen(text);
}
}

```

```

void    Dprintf(va_alist)

```

```

va_dcl

```

```

{
    va_list    ap;

    if (global->debug) {
        char    *format;

        va_start(ap);
        format=va_arg(ap,char *);
        vprintf(format,ap);
    }
}

```

- 262 -

```
        va_end(ap);
    }
}
```

```
void Mprintf(va_alist)
```

```
va_dcl
```

```
{
    va_list    ap;
    Message    msg;

    va_start(ap);
    msg = va_arg(ap, Message);
    mprintf(msg, ap);
    va_end(ap);
}
```

```
void Eprintf(va_alist)
```

```
va_dcl
```

```
{
    va_list    ap;
    Message    msg;
    int        rows, cols;

    va_start(ap);
    msg = NewMessage(NULL, STRLEN);
    mprintf(msg, ap);
    if (global->batch == NULL) {
        XtCallbackRec    callbacks[] = {
```

- 263 -

```
        {CloseMessage,(caddr_t)msg},  
        {NULL,NULL},  
    };  
  
    TextSize(msg);  
    MessageWindow(global->toplevel,msg,"Xwave Error",True,callbacks);  
}  
va_end(ap);  
}
```

- 264 -

source/NameButton.c

```
/*
 *      Supply MenuButton widget id to PullRightMenu button resource
 */

#include      "../include/xwave.h"

void  NameButton(w, event, params, num_params)

Widget      w;
XEvent      *event;
String *params;
Cardinal     *num_params;

{
    MenuButtonWidget  mbw=(MenuButtonWidget) w;
    Widget      menu;
    Arg  args[1];
    String name;
    XtSetArg(args[0],XtNmenuName,&name);
    XtGetValues(w,args,ONE);
    Dprintf("NameButton: looking for PRM %s\n",name);
    menu=FindWidget(name,w);
    if (menu != NULL) {
        Dprintf("NameButton: setting Menu Button\n");
        XtSetArg(args[0],XtNbutton.w);
        XtSetValues(menu,args,ONE);
    }
}
```



- 265 -

## source/Palette.c

```
/*
 *   Palette re-mapping
 */

#include    "../include/xwave.h"

/*   Function Name:    ReMap
 *   Description:    Re-maps a pixel value to a new value via a mapping
 *   Arguments:    pixel - pixel value (0..max-1)
 *                  max - range of pixel values
 *                  map - palette to recode with
 *   Returns:    remapped pixel value
 */

int    ReMap(pixel,max,palette)

int    pixel, max;
Palette    palette;

{
    Map    map=palette->mappings;
    int    value=pixel;
    Boolean    inrange=False;

    while(map!=NULL && !inrange) {
        if (pixel >=map->start && pixel <=map->finish) {
            inrange=True;
            value=map->m*pixel+map->c;
        }
    }
}
```

- 266 -

```

    }
    map=map->next;
}
return(value<0?0:value>=max?max-1:value);
}

```

```

/*  Function Name:      FindPalette
*   Description:   Find a palette from a list given the index
*   Arguments:    palette - the palette list
*                  index - the index number
*   Returns:      the palette corresponding to the index
*/

```

Palette      FindPalette(palette,index)

```

Palette      palette;
int      index;

{
    while(index>0 && palette->next!=NULL) {
        index--;
        palette=palette->next;
    }
    return(palette);
}

```

```

/*  Function Name:      ReOrderPalettes
*   Description:   Reverse the order of the palette list
*   Arguments:    start, finish - the start and finish of the re-ordered list
*   Returns:      the palette list in the reverse order
*/

```

- 267 -

Palette ReOrderPalettes(start,finish)

Palette start, finish;

```
{  
    Palette list=finish->next;  
  
    if (list!=NULL) {  
        finish->next=list->next;  
        list->next=start;  
        start=ReOrderPalettes(list,finish);  
    }  
    return(start);  
}
```

- 268 -

**source/Parse.c**

```
/*
 *   Parser for xwave input files: .elo
 */

#include    "../include/xwave.h"
#include    "../include/Gram.h"

void Parse(path,file,ext)

String path, file, ext;

{
    char file_name[STRLEN];

    sprintf(file_name,"%s%s/%s%s\0",global->home,path,file,ext);
    Dprintf("Parse: parsing file %s\n",file_name);
    if (NULL==(global->parse_fp=fopen(file_name,"r")))
        Eprintf("Parse: failed to open input file %s\n",file_name);
    else {
        sprintf(file_name,"%s%s\0",file,ext);
        global->parse_file=file_name;
        global->parse_token=ext;
        yyparse();
        fclose(global->parse_fp);
        Dprintf("Parse: finished with %s\n",file_name);
    }
}
```

- 269 -

```
void ParseCtrl(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t      closure, call_data;
```

```
{
```

```
    Parse(".",((XawListReturnStruct *)call_data)->string,(String)closure);
```

```
}
```

```
int ParseInput(fp)
```

```
FILE *fp;
```

```
{
```

```
    int num;
```

```
    if (global->parse_token!=NULL)
```

```
        if (global->parse_token[0]=='\0') {
```

```
            num=(int)'\n';
```

```
            global->parse_token=NULL;
```

```
        } else {
```

```
            num=(int)global->parse_token[0];
```

```
            global->parse_token++;
```

```
        }
```

```
    else if (EOF==(num=getc(global->parse_fp))) num=NULL;
```

```
    return(num);
```

```
}
```

- 270 -

## source/Pop2.c

```
/*
    Global callbacks for popping popups and allsorted utilities
*/

#include    "../include/xwave.h"

void Destroy(w,closure,call_data)

Widget      w;
caddr_t      closure, call_data;

{
    Widget      widget=(Widget)closure;

    if (widget!=NULL) XtDestroyWidget(widget);
}

void Quit(w,closure,call_data)

Widget      w;
caddr_t      closure, call_data;

{
    XtDestroyApplicationContext(global->app_con);
    exit();
}

void Free(w,closure,call_data)
```

- 271 -

```
Widget      w;
caddr_t     closure, call_data;
```

```
{
    if (closure != NULL) XtFree(closure);
}
```

```
Widget      FindWidget(name, current)
```

```
String name;
```

```
Widget      current;
```

```
{
    Widget      target=NULL;

    while(current != NULL) {
        target=XtNameToWidget(current, name);
        if (target == NULL) current=XtParent(current);
        else break;
    }
    if (target == NULL) {
        Eprintf("Cant find widget: %s\n", name);
        target=global->toplevel;
    }
    return(target);
}
```

```
#define      NA_ICONS 2
```

```
void  NA(w, closure, call_data)
```

```
Widget      w;
```

- 272 -

```

caddr_t      closure, call_data;

{
    Widget
shell=ShellWidget("na_shell",(Widget)closure,SW_below,NULL,NULL),
                form=FormatWidget("na_form",shell), widgets[NA_ICONS];
    FormItem  items[]={
        {"na_confirm","confirm",0,0,FW_icon,NULL},
        {"na_label","This function is not available",0,1,FW_label,NULL},
    };
    XtCallbackRec  callbacks[]={
        {Destroy,(caddr_t)shell}, {NULL,NULL},
    };

    FillForm(form,NA_ICONS,items,widgets,callbacks);
    XtPopup(shell,XtGrabExclusive);
}

```

```

void  SetSensitive(w,closure,call_data)

```

```

Widget      w;
caddr_t      closure, call_data;

{
    XtSetSensitive((Widget)closure,True);
}

```



- 273 -

## source/Process.c

```
/*
 *   Call sub-processes
 */

#include    "../include/xwave.h"
#include    <signal.h>
#include    <sys/wait.h>
#include    <sys/time.h>
#include    <sys/resource.h>

/*      Function Name:      Fork
 *      Description:  Executes a file in a process and waits for termination
 *      Arguments:      argv - standard argv argument description
 *      Returns:         dead process id
 */

int  Fork(argv)

char  *argv[];

{
    int  pid;
    union wait  statusp;
    struct rusage rusage;

    if (0==(pid=fork())) {
        execvp(argv[0],argv);
        exit();
    }
}
```

- 274 -

```

    } else if (pid > 0) wait4(pid,&statusp,0,&rusage);
    return(pid);
}

/*  Function Name:      zropen
 *  Description:   Open a file (or .Z file) for reading
 *  Arguments:    file_name - name of the file to be read
 *                pid - pointer to process id
 *  Returns:      file pointer
 */

FILE *zropen(file_name,pid)

char *file_name;
int *pid;

{
    char z_name[STRLEN];
    String zcat[]={"zcat",z_name,NULL};
    FILE *fp;

    if (NULL==(fp=fopen(file_name,"r"))) {
        static int up[2];

        sprintf(z_name,"%s.Z",file_name);
        pipe(up);
        if (0!=(*pid=fork())) {
            Dprintf("Parent process started\n");
            close(up[1]);
            fp=fdopen(up[0],"r");
        } else {
            Dprintf("Running zcat on %s\n",zcat[1]);

```

- 275 -

```

        close(up[0]);
        dup2( up[1], 1 );
        close( up[1] );
        execvp(zcat[0],zcat);
    }
}
return(fp);
}

/*  Function Name:    zseek
 *  Description:    Fast-forward thru file (fseek will not work on pipes)
 *  Arguments:    fp - file pointer
 *                  bytes - bytes to skip
 */

void  zseek(fp,bytes)

FILE  *fp;
int   bytes;

{
    char  scratch[1000];
    int   i;

    while(bytes > 0) {
        int   amount=bytes > 1000?1000:bytes;

        fread(scratch,sizeof(char),amount,fp);
        bytes-=amount;
    }
}

```

- 276 -

```
void  zclose(fp,pid)
```

```
FILE  *fp;
```

```
int   pid;
```

```
{
```

```
    union wait  statusp;
```

```
    struct rusage rusage;
```

```
    fclose(fp);
```

```
    if (pid!=0) wait4(pid,&statusp,0,&rusage);
```

```
}
```

- 277 -

source/PullRightMenu.c

```
#if ( !defined(lint) && !defined(SABER) )
```

```
static char Xrcsid[] = "$XConsortium: PullRightMenu.c,v 1.32 89/12/11 15:01:50 kit  
Exp $";
```

```
#endif
```

```
/*
```

```
* Copyright 1989 Massachusetts Institute of Technology
```

```
*
```

```
* Permission to use, copy, modify, distribute, and sell this software and its  
* documentation for any purpose is hereby granted without fee, provided that  
* the above copyright notice appear in all copies and that both that  
* copyright notice and this permission notice appear in supporting  
* documentation, and that the name of M.I.T. not be used in advertising or  
* publicity pertaining to distribution of the software without specific,  
* written prior permission. M.I.T. makes no representations about the  
* suitability of this software for any purpose. It is provided "as is"  
* without express or implied warranty.
```

```
*
```

```
* M.I.T. DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS SOFTWARE.  
INCLUDING ALL
```

```
* IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS, IN NO  
EVENT SHALL M.I.T.
```

```
* BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES  
OR ANY DAMAGES
```

```
* WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS,  
WHETHER IN AN ACTION
```

```
* OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS ACTION, ARISING OUT  
OF OR IN
```

- 278 -

```

* CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.
*/

/*
* PullRightMenu.c - Source code file for PullRightMenu widget.
*
*/

#include <stdio.h>
#include <X11/IntrinsicP.h>
#include <X11/StringDefs.h>

#include <X11/Xaw/XawInit.h>
#include <X11/Xaw/SimpleMenP.h>
#include "PullRightMenuP.h"
#include <X11/Xaw/SmeBSB.h>
#include "SmeBSBpr.h"
#include <X11/Xaw/Cardinals.h>

#include <X11/Xmu/Initer.h>
#include <X11/Xmu/CharSet.h>

#define streq(a, b)      ( strcmp((a), (b)) == 0 )

#define offset(field) XtOffset(PullRightMenuWidget, simple_menu.field)

static XtResource resources[] = {

/*
* Label Resources.
*/

```

- 279 -

```
{XtNlabel, XtCLabel, XtRString, sizeof(String),
  offset(label_string), XtRString, NULL},
{XtNlabelClass, XtCLabelClass, XtRPointer, sizeof(WidgetClass),
  offset(label_class), XtRImmediate, (caddr_t) NULL},
```

/\*

\* Layout Resources.

\*/

```
{XtNrowHeight, XtCRowHeight, XtRDimension, sizeof(Dimension),
  offset(row_height), XtRImmediate, (caddr_t) 0},
{XtNtopMargin, XtCVerticalMargins, XtRDimension, sizeof(Dimension),
  offset(top_margin), XtRImmediate, (caddr_t) 0},
{XtNbottomMargin, XtCVerticalMargins, XtRDimension, sizeof(Dimension),
  offset(bottom_margin), XtRImmediate, (caddr_t) 0},
```

/\*

\* Misc. Resources

\*/

```
{ XtNallowShellResize, XtCAllowShellResize, XtRBoolean, sizeof(Boolean),
  XtOffset(SimpleMenuWidget, shell.allow_shell_resize),
  XtRImmediate, (XtPointer) TRUE },
{XtNcursor, XtCCursor, XtRCursor, sizeof(Cursor),
  offset(cursor), XtRImmediate, (caddr_t) None},
{XtNmenuOnScreen, XtCMenuOnScreen, XtRBoolean, sizeof(Boolean),
  offset(menu_on_screen), XtRImmediate, (caddr_t) TRUE},
{XtNpopupOnEntry, XtCPopupOnEntry, XtRWidget, sizeof(Widget),
  offset(popup_entry), XtRWidget, NULL},
{XtNbackingStore, XtCBackingStore, XtRBackingStore, sizeof(int),
  offset(backing_store),
  XtRImmediate, (caddr_t) (Always + WhenMapped + NotUseful)},
```

- 280 -

```
{XtNbutton, XtCWidget, XtRWidget, sizeof(Widget),
    offset(button), XtRWidget, (XtPointer)NULL},
};
#undef offset

static char defaultTranslations[] =
    "<EnterWindow>:    highlight()    \n\
    <LeaveWindow>:     pull()          \n\
    <BtnMotion>:       highlight()    \n\
    <BtnUp>:           execute()";

/*
 * Semi Public function definitions.
 */

static void Redisplay(), Realize(), Resize(), ChangeManaged();
static void Initialize(), ClassInitialize(), ClassPartInitialize();
static Boolean SetValues(), SetValuesHook();
static XtGeometryResult GeometryManager();

/*
 * Action Routine Definitions
 */

static void Highlight(), Unhighlight(), Pull(), Execute(), Notify(), PositionMenuAction();

/*
 * Private Function Definitions.
 */

static void MakeSetValuesRequest(), CreateLabel(), Layout();
static void AddPositionAction(), PositionMenu(), ChangeCursorOnGrab();
```



- 281 -

```
static Dimension GetMenuWidth(), GetMenuHeight();
static Widget FindMenu();
static SmeObject GetEventEntry();
```

```
static XtActionsRec actionsList[] =
{
    {"pull",          Pull},
    {"execute",       Execute},
    {"notify",        Notify},
    {"highlight",     Highlight},
    {"unhighlight",   Unhighlight},
};
```

```
CompositeClassExtensionRec pr_extension_rec = {
    /* next_extension */ NULL,
    /* record_type */    NULLQUARK,
    /* version */        XtCompositeExtensionVersion,
    /* record_size */    sizeof(CompositeClassExtensionRec),
    /* accepts_objects */ TRUE,
};
```

```
#define superclass (&overrideShellClassRec)
```

```
PullRightMenuClassRec pullRightMenuClassRec = {
    {
        /* superclass */    (WidgetClass) superclass,
        /* class_name */    "PullRightMenu",
        /* size */          sizeof(PullRightMenuRec),
        /* class_initialize */ ClassInitialize,
        /* class_part_initialize*/ ClassPartInitialize,
        /* Class init'ed */  FALSE,
        /* initialize */    Initialize,
    }
};
```

- 282 -

```

/* initialize_hook */ NULL,
/* realize */ Realize,
/* actions */ actionsList,
/* num_actions */ XtNumber(actionsList),
/* resources */ resources,
/* resource_count */ XtNumber(resources),
/* xrm_class */ NULLQUARK,
/* compress_motion */ TRUE,
/* compress_exposure */ TRUE,
/* compress_enterleave*/ TRUE,
/* visible_interest */ FALSE,
/* destroy */ NULL,
/* resize */ Resize,
/* expose */ Redisplay,
/* set_values */ SetValues,
/* set_values_hook */ SetValuesHook,
/* set_values_almost */ XtInheritSetValuesAlmost,
/* get_values_hook */ NULL,
/* accept_focus */ NULL,
/* intrinsics version */ XtVersion,
/* callback offsets */ NULL,
/* tm_table */ defaultTranslations,
/* query_geometry */ NULL,
/* display_accelerator*/ NULL,
/* extension */ NULL
},{
/* geometry_manager */ GeometryManager,
/* change_managed */ ChangeManaged,
/* insert_child */ XtInheritInsertChild,
/* delete_child */ XtInheritDeleteChild,
/* extension */ NULL
},{

```

- 283 -

```

    /* Shell extension      */  NULL
}, {
    /* Override extension */  NULL
}, {
    /* Simple Menu extension*/  NULL
}
};

```

```
WidgetClass pullRightMenuWidgetClass = (WidgetClass)&pullRightMenuClassRec;
```

```

/*****
 *
 * Semi-Public Functions.
 *
 *****/

```

```

/*    Function Name: ClassInitialize
 *    Description: Class Initialize routine, called only once.
 *    Arguments: none.
 *    Returns: none.
 */

```

```

static void
ClassInitialize()
{
    XawInitializeWidgetSet();
    XtAddConverter( XtRString, XtRBackingStore, XmuCvtStringToBackingStore,
                   NULL, 0 );
    XmuAddInitializer( AddPositionAction, NULL);
}

```

```
/*    Function Name: ClassInitialize
```

- 284 -

```

*   Description: Class Part Initialize routine, called for every
*               subclass. Makes sure that the subclasses pick up
*               the extension record.
*   Arguments: wc - the widget class of the subclass.
*   Returns: none.
*/

```

```
static void
```

```
ClassPartInitialize(wc)
```

```
WidgetClass wc;
```

```
{
```

```
    SimpleMenuWidgetClass smwc = (SimpleMenuWidgetClass) wc;
```

```
/*
```

```
* Make sure that our subclass gets the extension rec too.
```

```
*/
```

```
    pr_extension_rec.next_extension = smwc->composite_class.extension;
```

```
    smwc->composite_class.extension = (caddr_t) &pr_extension_rec;
```

```
}
```

```
/*   Function Name: Initialize
```

```
*   Description: Initializes the simple menu widget
```

```
*   Arguments: request - the widget requested by the argument list.
```

```
*               new      - the new widget with both resource and non
```

```
*               resource values.
```

```
*   Returns: none.
```

```
*/
```

```
/* ARGSUSED */
```

```
static void
```

```
Initialize(request, new)
```

- 285 -

```
Widget request, new;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) new;

    XmuCallInitializers(XtWidgetToApplicationContext(new));

    if (smw->simple_menu.label_class == NULL)
        smw->simple_menu.label_class = smeBSBObjectClass;

    smw->simple_menu.label = NULL;
    smw->simple_menu.entry_set = NULL;
    smw->simple_menu.recursive_set_values = FALSE;

    if (smw->simple_menu.label_string != NULL)
        CreateLabel(new);

    smw->simple_menu.menu_width = TRUE;

    if (smw->core.width == 0) {
        smw->simple_menu.menu_width = FALSE;
        smw->core.width = GetMenuWidth(new, NULL);
    }

    smw->simple_menu.menu_height = TRUE;

    if (smw->core.height == 0) {
        smw->simple_menu.menu_height = FALSE;
        smw->core.height = GetMenuHeight(new);
    }

    /*
    * Add a popup_callback routine for changing the cursor.
```

- 286 -

\*/

```
XtAddCallback(new, XtNpopupCallback, ChangeCursorOnGrab, NULL);
}
```

```
/*    Function Name: Redisplay
 *    Description: Redisplays the contents of the widget.
 *    Arguments: w - the simple menu widget.
 *               event - the X event that caused this redisplay.
 *               region - the region the needs to be repainted.
 *    Returns: none.
 */
```

/\* ARGSUSED \*/

static void

Redisplay(w, event, region)

Widget w;

XEvent \* event;

Region region;

{

SimpleMenuWidget smw = (SimpleMenuWidget) w;

SmeObject \* entry;

SmeObjectClass class;

if (region == NULL)

XClearWindow(XtDisplay(w), XtWindow(w));

/\*

\* Check and Paint each of the entries - including the label.

\*/

ForAllChildren(smw, entry) {

- 287 -

```

if (!XtIsManaged ( (Widget) *entry)) continue;

if (region != NULL)
    switch(XRectInRegion(region, (int) (*entry)->rectangle.x,
        (int) (*entry)->rectangle.y,
        (unsigned int) (*entry)->rectangle.width,
        (unsigned int) (*entry)->rectangle.height)) {
        case RectangleIn:
        case RectanglePart:
            break;
        default:
            continue;
    }
class = (SmeObjectClass) (*entry)->object.widget_class;

if (class->rect_class.expose != NULL)
    (class->rect_class.expose)( (Widget) *entry, NULL, NULL);
}
}

```

```

/*  Function Name: Realize
*   Description: Realizes the widget.
*   Arguments: w - the simple menu widget.
*              mask - value mask for the window to create.
*              attrs - attributes for the window to create.
*   Returns: none
*/

```

```
static void
```

```
Realize(w, mask, attrs)
```

```
Widget w;
```

```
XtValueMask * mask;
```

- 288 -

```

XSetWindowAttributes * attrs;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;

    attrs->cursor = smw->simple_menu.cursor;
    *mask |= CWCursor;
    if ((smw->simple_menu.backing_store == Always) ||
        (smw->simple_menu.backing_store == NotUseful) ||
        (smw->simple_menu.backing_store == WhenMapped) ) {
        *mask |= CWBackingStore;
        attrs->backing_store = smw->simple_menu.backing_store;
    }
    else
        *mask &= ~CWBackingStore;

    (*superclass->core_class.realize) (w, mask, attrs);
}

/*    Function Name: Resize
 *    Description: Handle the menu being resized bigger.
 *    Arguments: w - the simple menu widget.
 *    Returns: none.
 */

static void
Resize(w)
Widget w;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject * entry;

    if ( !XtIsRealized(w) ) return;

```



- 289 -

```

ForAllChildren(smw, entry)    /* reset width of all entries. */
    if (XtIsManaged( (Widget) *entry))
        (*entry)->rectangle.width = smw->core.width;

Redisplay(w, (XEvent *) NULL, (Region) NULL);
}

/*  Function Name: SetValues
 *  Description: Relayout the menu when one of the resources is changed.
 *  Arguments: current - current state of the widget.
 *              request - what was requested.
 *              new - what the widget will become.
 *  Returns: none
 */

/* ARGSUSED */
static Boolean
SetValues(current, request, new)
Widget current, request, new;
{
    SimpleMenuWidget smw_old = (SimpleMenuWidget) current;
    SimpleMenuWidget smw_new = (SimpleMenuWidget) new;
    Boolean ret_val = FALSE, layout = FALSE;

    if (!XtIsRealized(current)) return(FALSE);

    if (!smw_new->simple_menu.recursive_set_values) {
        if (smw_new->core.width != smw_old->core.width) {
            smw_new->simple_menu.menu_width = (smw_new->core.width != 0);
            layout = TRUE;
        }

        if (smw_new->core.height != smw_old->core.height) {

```

- 290 -

```

        smw_new->simple_menu.menu_height = (smw_new->core.height != 0);
        layout = TRUE;
    }
}

if (smw_old->simple_menu.cursor != smw_new->simple_menu.cursor)
    XDefineCursor(XtDisplay(new),
        XtWindow(new), smw_new->simple_menu.cursor);

if (smw_old->simple_menu.label_string != smw_new->simple_menu.label_string)
    if (smw_new->simple_menu.label_string == NULL)        /* Destroy. */
        XtDestroyWidget(smw_old->simple_menu.label);
    else if (smw_old->simple_menu.label_string == NULL)    /* Create. */
        CreateLabel(new);
    else {
        /* Change. */
        Arg args[1];

        XtSetArg(args[0], XtNlabel, smw_new->simple_menu.label_string);
        XtSetValues(smw_new->simple_menu.label, args, ONE);
    }

if (smw_old->simple_menu.label_class != smw_new->simple_menu.label_class)
    XtAppWarning(XtWidgetToApplicationContext(new),
        "No Dynamic class change of the SimpleMenu Label.");

if ((smw_old->simple_menu.top_margin != smw_new->simple_menu.top_margin)
||
    (smw_old->simple_menu.bottom_margin !=
    smw_new->simple_menu.bottom_margin) /* filler..... */ ) {
    layout = TRUE;
    ret_val = TRUE;
}

```

- 291 -

```
    if (layout)
        Layout(new, NULL, NULL);

    return(ret_val);
}

/*    Function Name: SetValuesHook
 *    Description: To handle a special case, this is passed the
 *                actual arguments.
 *    Arguments: w - the menu widget.
 *                arglist - the argument list passed to XtSetValues.
 *                num_args - the number of args.
 *    Returns: none
 */

/*
 * If the user actually passed a width and height to the widget
 * then this MUST be used, rather than our newly calculated width and
 * height.
 */

static Boolean
SetValuesHook(w, arglist, num_args)
Widget w;
ArgList arglist;
Cardinal *num_args;
{
    register Cardinal i;
    Dimension width, height;

    width = w->core.width;
    height = w->core.height;
```

- 292 -

```

    for ( i = 0 ; i < *num_args ; i++ ) {
        if ( streq(arglist[i].name, XtNwidth) )
            width = (Dimension) arglist[i].value;
        if ( streq(arglist[i].name, XtNheight) )
            height = (Dimension) arglist[i].value;
    }

    if ((width != w->core.width) || (height != w->core.height))
        MakeSetValuesRequest(w, width, height);
    return(FALSE);
}

/*****
 *
 * Geometry Management routines.
 *
 *****/

/*      Function Name: GeometryManager
 *      Description: This is the SimpleMenu Widget's Geometry Manager.
 *      Arguments: w - the Menu Entry making the request.
 *                  request - requested new geometry.
 *                  reply - the allowed geometry.
 *      Returns: XtGeometry{ Yes, No, Almost}.
 */

static XtGeometryResult
GeometryManager(w, request, reply)
Widget w;
XtWidgetGeometry * request, * reply;
{

```

- 293 -

```
SimpleMenuWidget smw = (SimpleMenuWidget) XtParent(w);
```

```
SmeObject entry = (SmeObject) w;
```

```
XtGeometryMask mode = request->request_mode;
```

```
XtGeometryResult answer;
```

```
Dimension old_height, old_width;
```

```
if ( !(mode & CWWidth) && !(mode & CWHeight) )
```

```
    return(XtGeometryNo);
```

```
reply->width = request->width;
```

```
reply->height = request->height;
```

```
old_width = entry->rectangle.width;
```

```
old_height = entry->rectangle.height;
```

```
Layout(w, &(reply->width), &(reply->height) );
```

```
/*
```

```
* Since we are an override shell and have no parent there is no one to  
* ask to see if this geom change is okay, so I am just going to assume  
* we can do whatever we want. If you subclass be very careful with this  
* assumption, it could bite you.
```

```
*
```

```
* Chris D. Peterson - Sept. 1989.
```

```
*/
```

```
if ( (reply->width == request->width) &&  
    (reply->height == request->height) ) {
```

```
    if ( mode & XtCWQueryOnly ) { /* Actually perform the layout. */
```

```
        entry->rectangle.width = old_width;
```

```
        entry->rectangle.height = old_height;
```

- 294 -

```

    }
    else {
        Layout(( Widget) smw, NULL, NULL);
    }
    answer = XtGeometryDone;
}
else {
    entry->rectangle.width = old_width;
    entry->rectangle.height = old_height;

    if ( ((reply->width == request->width) && !(mode & CWHeight)) ||
        ((reply->height == request->height) && !(mode & CWWidth)) ||
        ((reply->width == request->width) &&
         (reply->height == request->height)) )
        answer = XtGeometryNo;
    else {
        answer = XtGeometryAlmost;
        reply->request_mode = 0;
        if (reply->width != request->width)
            reply->request_mode |= CWWidth;
        if (reply->height != request->height)
            reply->request_mode |= CWHeight;
    }
}
return(answer);
}

```

```

/*  Function Name: ChangeManaged
*
*  Description: called whenever a new child is managed.
*
*  Arguments: w - the simple menu widget.
*
*  Returns: none..
*/

```

- 295 -

static void

ChangeManaged(w)

Widget w;

{

Layout(w, NULL, NULL);

}

/\*\*\*\*\*

\*

\* Global Action Routines.

\*

\* These actions routines will be added to the application's

\* global action list.

\*

\*\*\*\*\*/

/\* Function Name: PositionMenuAction

\* Description: Positions the simple menu widget.

\* Arguments: w - a widget (no the simple menu widget.)

\* event - the event that caused this action.

\* params. num\_params - parameters passed to the routine.

\* we expect the name of the menu here.

\* Returns: none

\*/

/\* ARGSUSED \*/

static void

PositionMenuAction(w, event, params, num\_params)

Widget w;

XEvent \* event;

String \* params;

Cardinal \* num\_params;

- 296 -

```
{
Widget menu;
XPoint loc;

if (*num_params != 1) {
    char error_buf[BUFSIZ];
    sprintf(error_buf, "%s %s",
            "Xaw - SimpleMenuWidget: position menu action expects only one",
            "parameter which is the name of the menu.");
    XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
    return;
}

if ( (menu = FindMenu(w, params[0])) == NULL) {
    char error_buf[BUFSIZ];
    sprintf(error_buf, "%s '%s'",
            "Xaw - SimpleMenuWidget: could not find menu named: ", params[0]);
    XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
    return;
}

switch (event->type) {
case ButtonPress:
case ButtonRelease:
    loc.x = event->xbutton.x_root;
    loc.y = event->xbutton.y_root;
    PositionMenu(menu, &loc);
    break;
case EnterNotify:
case LeaveNotify:
    loc.x = event->xcrossing.x_root;
    loc.y = event->xcrossing.y_root;
```



- 297 -

```

    PositionMenu(menu, &loc);
    break;
case MotionNotify:
    loc.x = event->xmotion.x_root;
    loc.y = event->xmotion.y_root;
    PositionMenu(menu, &loc);
    break;
default:
    PositionMenu(menu, NULL);
    break;
}
}

/*****
 *
 * Widget Action Routines.
 *
 *****/

/*  Function Name: Unhighlight
 *  Description: Unhighlights current entry.
 *  Arguments: w - the simple menu widget.
 *              event - the event that caused this action.
 *              params, num_params - ** NOT USED **
 *  Returns: none
 */

/* ARGSUSED */
static void
Unhighlight(w, event, params, num_params)
Widget w;
XEvent * event;

```

- 298 -

```

String * params;
Cardinal * num_params;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject entry = smw->simple_menu.entry_set;
    SmeObjectClass class;

    if ( entry == NULL) return;

    smw->simple_menu.entry_set = NULL;
    class = (SmeObjectClass) entry->object.widget_class;
    (class->sme_class.unhighlight) ( (Widget) entry);
}

/*    Function Name: Highlight
 *    Description: Highlights current entry.
 *    Arguments: w - the simple menu widget.
 *               event - the event that caused this action.
 *               params, num_params - ** NOT USED **
 *    Returns: none
 */

/* ARGSUSED */
static void
Highlight(w, event, params, num_params)
Widget w;
XEvent * event;
String * params;
Cardinal * num_params;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject entry;

```

- 299 -

```

SmeObjectClass class;

if ( !XtIsSensitive(w) ) return;

entry = GetEventEntry(w, event);

if (entry == smw->simple_menu.entry_set) return;

Unhighlight(w, event, params, num_params);

if (entry == NULL) return;

if ( !XtIsSensitive( (Widget) entry)) {
    smw->simple_menu.entry_set = NULL;
    return;
}

smw->simple_menu.entry_set = entry;
class = (SmeObjectClass) entry->object.widget_class;

(class->sme_class.highlight) ( (Widget) entry);
}

/*    Function Name: Notify
 *    Description: Notify user of current entry.
 *    Arguments: w - the simple menu widget.
 *               event - the event that caused this action.
 *               params, num_params - ** NOT USED **
 *    Returns: none
 */

/* ARGSUSED */

```

- 300 -

```

static void
Notify(w, event, params, num_params)
Widget w;
XEvent * event;
String * params;
Cardinal * num_params;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject entry = smw->simple_menu.entry_set;
    SmeObjectClass class;

    if ( (entry == NULL) || !XtIsSensitive((Widget) entry) ) return;

    class = (SmeObjectClass) entry->object.widget_class;
    (class->sme_class.notify)( (Widget) entry );
}

/*    Function Name: Pull
 *    Description: Determines action on basis of leave direction.
 *    Arguments: w - the pull right menu widget.
 *                event - the LeaveWindow event that caused this action.
 *                params, num_params - ** NOT USED **
 *    Returns: none
 */

```

```

static void Pull(w, event, params, num_params)

```

```

Widget      w;
XEvent      *event;
String *params;
Cardinal     *num_params;

```

- 301 -

```

{
    PullRightMenuWidget    prw=(PullRightMenuWidget)w;
    SmeObject    entry=prw->simple_menu.entry_set;
    SmeObjectClass    class;

    if ((entry == NULL) || !XtIsSensitive((Widget)entry))return;
    if (event->type!=LeaveNotify && event->type!=EnterNotify) {
        XtAppError(XtWidgetToApplicationContext(w),
            "pull() action should only be used with XCrossing events.");
        return;
    }
    if (None!=event->xcrossing.subwindow) return;
    if (event->xcrossing.y < 0 || event->xcrossing.y > prw->core.height) {
        Unhighlight(w,event,params,num_params);
        return;
    };
    if (event->xcrossing.x < 0) {
        if (XtIsSubclass(XtParent(w),pullRightMenuWidgetClass)) XtPopdown(w);
        return;
    };
    class=(SmeObjectClass)entry->object.widget_class;
    if (event->xcrossing.x > prw->core.width &&
XtIsSubclass(entry,smeBSBprObjectClass)) (class->sme_class.notify)((Widget)entry);
    else Unhighlight(w,event,params,num_params);
}

/*  Function Name: Execute
*
*  Description: Determines notify action on basis of SmeObject.
*
*  Arguments: w - the pull right menu widget.
*
*              event - the notify-type event that caused this action.
*
*              params, num_params - ** NOT USED **
*
*  Returns: none

```

- 302 -

```

*/

static void Execute(w, event, params, num_params)

Widget      w;
XEvent      *event;
String *params;
Cardinal     *num_params;

{
    PullRightMenuWidget    prw=(PullRightMenuWidget)w;
    SmeObject    entry=prw->simple_menu.entry_set;
    SmeObjectClass    class;
    Widget      shell;

    Dprintf("Execute\n");
    for(shell=w;XtIsSubclass(shell,pullRightMenuWidgetClass);shell=XtParent(shell))
    {
        XawSimpleMenuClearActiveEntry(shell);
        XtPopdown(shell);
    };
    if
    ((entry==GetEventEntry(w,event))&&(entry!=NULL)&&XtIsSensitive((Widget)entry)) {
        class=(SmeObjectClass)entry->object.widget_class;
        if (XtIsSubclass(entry,smeBSBObjectClass))
        (class->sme_class.notify)((Widget)entry);
    };
}

```

```

/*****

```

- 303 -

\*

\* Public Functions.

\*

\*\*\*\*\*/

/\* Function Name: XawPullRightMenuAddGlobalActions

\* Description: adds the global actions to the simple menu widget.

\* Arguments: app\_con - the appcontext.

\* Returns: none.

\*/

void

XawPullRightMenuAddGlobalActions(app\_con)

XtAppContext app\_con;

{

XtInitializeWidgetClass(pullRightMenuWidgetClass);

XmuCallInitializers( app\_con );

}

\*\*\*\*\*/

\*

\* Private Functions.

\*

\*\*\*\*\*/

/\* Function Name: CreateLabel

\* Description: Creates a the menu label.

\* Arguments: w - the smw widget.

\* Returns: none.

\*

\* Creates the label object and makes sure it is the first child in

\* in the list.

- 304 -

\*/

static void

CreateLabel(w)

Widget w;

{

SimpleMenuWidget smw = (SimpleMenuWidget) w;

register Widget \* child, \* next\_child;

register int i;

Arg args[2];

if ( (smw-&gt;simple\_menu.label\_string == NULL) ||

(smw-&gt;simple\_menu.label != NULL) ) {

char error\_buf[BUFSIZ];

sprintf(error\_buf, "Xaw Simple Menu Widget: %s or %s, %s",

"label string is NULL", "label already exists",

"no label is being created.");

XtAppWarning(XtWidgetToApplicationContext(w), error\_buf);

return;

}

XtSetArg(args[0], XtNlabel, smw-&gt;simple\_menu.label\_string);

XtSetArg(args[1], XtNjustify, XtJustifyCenter);

smw-&gt;simple\_menu.label = (SmeObject)

XtCreateManagedWidget("menuLabel",

smw-&gt;simple\_menu.label\_class, w,

args, TWO);

next\_child = NULL;

for (child = smw-&gt;composite.children + smw-&gt;composite.num\_children,

i = smw-&gt;composite.num\_children ; i &gt; 0 ; i--, child--) {



- 305 -

```

    if (next_child != NULL)
        *next_child = *child;
    next_child = child;
}
*child = (Widget) smw->simple_menu.label;
}

/*  Function Name: Layout
 *  Description: lays the menu entries out all nice and neat.
 *  Arguments: w - See below (+++)
 *              width_ret, height_ret - The returned width and
 *                                      height values.
 *  Returns: none.
 *
 *  if width == NULL || height == NULL then it assumes the you do not care
 *  about the return values, and just want a relayout.
 *
 *  if this is not the case then it will set width_ret and height_ret
 *  to be width and height that the child would get if it were layed out
 *  at this time.
 *
 *  +++ "w" can be the simple menu widget or any of its object children.
 */

```

```
static void
```

```
Layout(w, width_ret, height_ret)
```

```
Widget w;
```

```
Dimension *width_ret, *height_ret;
```

```
{
```

```
    SmeObject current_entry, *entry;
```

```
    SimpleMenuWidget smw;
```

```
    Dimension width, height;
```

- 306 -

```

Boolean do_layout = ((height_ret == NULL) || (width_ret == NULL));
Boolean allow_change_size;
height = 0;

if ( XtIsSubclass(w, puliRightMenuWidgetClass) ) {
    smw = (SimpleMenuWidget) w;
    current_entry = NULL;
}
else {
    smw = (SimpleMenuWidget) XtParent(w);
    current_entry = (SmeObject) w;
}

allow_change_size = (!XtIsRealized((Widget)smw) ||
                    (smw->shell.allow_shell_resize));

if ( smw->simple_menu.menu_height )
    height = smw->core.height;
else
    if (do_layout) {
        height = smw->simple_menu.top_margin;
        ForAllChildren(smw, entry) {
            if (!XtIsManaged( (Widget) *entry)) continue;

            if ( (smw->simple_menu.row_height != 0) &&
                (*entry != smw->simple_menu.label) )
                (*entry)->rectangle.height = smw->simple_menu.row_height;

            (*entry)->rectangle.y = height;
            (*entry)->rectangle.x = 0;
            height += (*entry)->rectangle.height;
        }
    }

```

- 307 -

```

        height += smw->simple_menu.bottom_margin;
    }
    else {
        if ((smw->simple_menu.row_height != 0) &&
            (current_entry != smw->simple_menu.label) )
            height = smw->simple_menu.row_height;
    }

    if (smw->simple_menu.menu_width)
        width = smw->core.width;
    else if ( allow_change_size )
        width = GetMenuWidth((Widget) smw, (Widget) current_entry);
    else
        width = smw->core.width;

    if (do_layout) {
        ForAllChildren(smw, entry)
            if (XtIsManaged( (Widget) *entry))
                (*entry)->rectangle.width = width;

        if (allow_change_size)
            MakeSetValuesRequest((Widget) smw, width, height);
    }
    else {
        *width_ret = width;
        if (height != 0)
            *height_ret = height;
    }
}

/*      Function Name: AddPositionAction
*      Description: Adds the XawPositionSimpleMenu action to the global

```

- 308 -

```

*           action list for this appcon.
*   Arguments: app_con - the application context for this app.
*           data - NOT USED.
*   Returns: none.
*/

/* ARGSUSED */
static void
AddPositionAction(app_con, data)
XtAppContext app_con;
caddr_t data;
{
    static XtActionsRec pos_action[] = {
        { "XawPositionSimpleMenu", PositionMenuAction },
    };

    XtAppAddActions(app_con, pos_action, XtNumber(pos_action));
}

/*   Function Name: FindMenu
*   Description: Find the menu give a name and reference widget.
*   Arguments: widget - reference widget.
*           name - the menu widget's name.
*   Returns: the menu widget or NULL.
*/

static Widget
FindMenu(widget, name)
Widget widget;
String name;
{
    register Widget w, menu;

```

- 309 -

```

for ( w = widget ; w != NULL ; w = XtParent(w) )
    if ( (menu = XtNameToWidget(w, name)) != NULL )
        return(menu);
return(NULL);
}

```

```

/*    Function Name: PositionMenu
 *    Description: Places the menu
 *    Arguments: w - the simple menu widget.
 *               location - a pointer the the position or NULL.
 *    Returns: none.
 */

```

```
static void
```

```
PositionMenu(w, location)
```

```
Widget w;
```

```
XPoint * location;
```

```
{
```

```
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
```

```
    SmeObject entry;
```

```
    XPoint t_point;
```

```
    static void MoveMenu();
```

```
    if (location == NULL) {
```

```
        Window junk1, junk2;
```

```
        int root_x, root_y, junkX, junkY;
```

```
        unsigned int junkM;
```

```
        location = &t_point;
```

```
        if (XQueryPointer(XtDisplay(w), XtWindow(w), &junk1, &junk2,
```

```
                &root_x, &root_y, &junkX, &junkY, &junkM) == FALSE) {
```

- 310 -

```

    char error_buf[BUFSIZ];
    sprintf(error_buf, "%s %s", "Xaw - SimpleMenuWidget:",
            "Could not find location of mouse pointer");
    XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
    return;
}

location->x = (short) root_x;
location->y = (short) root_y;
}

/*
 * The width will not be correct unless it is realized.
 */

XtRealizeWidget(w);

location->x -= (Position) w->core.width/2;

if (smw->simple_menu.popup_entry == NULL)
    entry = smw->simple_menu.label;
else
    entry = smw->simple_menu.popup_entry;

if (entry != NULL)
    location->y -= entry->rectangle.y + entry->rectangle.height/2;

MoveMenu(w, (Position) location->x, (Position) location->y);
}

/*  Function Name: MoveMenu
 *  Description: Actually moves the menu, may force it to
 *               to be fully visable if menu_on_screen is TRUE.

```

- 311 -

```
*   Arguments: w - the simple menu widget.  
*           x, y - the current location of the widget.  
*   Returns: none  
*/
```

```
static void
```

```
MoveMenu(w, x, y)
```

```
Widget w;
```

```
Position x, y;
```

```
{
```

```
    Arg arglist[2];
```

```
    Cardinal num_args = 0;
```

```
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
```

```
    if (smw->simple_menu.menu_on_screen) {
```

```
        int width = w->core.width + 2 * w->core.border_width;
```

```
        int height = w->core.height + 2 * w->core.border_width;
```

```
        if (x < 0)
```

```
            x = 0;
```

```
        else {
```

```
            int scr_width = WidthOfScreen(XtScreen(w));
```

```
            if (x + width > scr_width)
```

```
                x = scr_width - width;
```

```
        }
```

```
        if (y < 0)
```

```
            y = 0;
```

```
        else {
```

```
            int scr_height = HeightOfScreen(XtScreen(w));
```

```
            if (y + height > scr_height)
```

```
                y = scr_height - height;
```

- 312 -

```

    }
}

XtSetArg(arglist[num_args], XtNx, x); num_args++;
XtSetArg(arglist[num_args], XtNy, y); num_args++;
XtSetValues(w, arglist, num_args);
}

/*    Function Name: ChangeCursorOnGrab
 *    Description: Changes the cursor on the active grab to the one
 *                specified in our resource list.
 *    Arguments: w - the widget.
 *                junk, garbage - ** NOT USED **.
 *    Returns: None.
 */

/* ARGSUSED */
static void
ChangeCursorOnGrab(w, junk, garbage)
Widget w;
caddr_t junk, garbage;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;

    /*
     * The event mask here is what is currently in the MIT implementation.
     * There really needs to be a way to get the value of the mask out
     * of the toolkit (CDP 5/26/89).
     */

    XChangeActivePointerGrab(XtDisplay(w), ButtonPressMask|ButtonReleaseMask,
                             smw->simple_menu.cursor, CurrentTime);

```



- 313 -

}

```

/*  Function Name: MakeSetValuesRequest
*   Description: Makes a (possibly recursive) call to SetValues,
*               I take great pains to not go into an infinite loop.
*   Arguments: w - the simple menu widget.
*               width, height - the size of the ask for.
*   Returns: none
*/

```

```

static void

```

```

MakeSetValuesRequest(w, width, height)

```

```

Widget w;

```

```

Dimension width, height;

```

```

{

```

```

    SimpleMenuWidget smw = (SimpleMenuWidget) w;

```

```

    Arg arglist[2];

```

```

    Cardinal num_args = (Cardinal) 0;

```

```

    if ( !smw->simple_menu.recursive_set_values ) {

```

```

        if ( (smw->core.width != width) || (smw->core.height != height) ) {

```

```

            smw->simple_menu.recursive_set_values = TRUE;

```

```

            XtSetArg(arglist[num_args], XtNwidth, width);  num_args++;

```

```

            XtSetArg(arglist[num_args], XtNheight, height); num_args++;

```

```

            XtSetValues(w, arglist, num_args);

```

```

        }

```

```

        else if (XtIsRealized( (Widget) smw))

```

```

            Redisplay((Widget) smw, (XEvent *) NULL, (Region) NULL);

```

```

    }

```

```

    smw->simple_menu.recursive_set_values = FALSE;

```

```

}

```

- 314 -

```

/*    Function Name: GetMenuWidth
*    Description: Sets the length of the widest entry in pixels.
*    Arguments: w - the simple menu widget.
*    Returns: width of menu.
*/

```

```
static Dimension
```

```
GetMenuWidth(w, w_ent)
```

```
Widget w, w_ent;
```

```
{
```

```
    SmeObject cur_entry = (SmeObject) w_ent;
```

```
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
```

```
    Dimension width, widest = (Dimension) 0;
```

```
    SmeObject * entry;
```

```
    if ( smw->simple_menu.menu_width )
```

```
        return(smw->core.width);
```

```
    ForAllChildren(smw, entry) {
```

```
        XtWidgetGeometry preferred;
```

```
        if (!XtIsManaged( (Widget) *entry)) continue;
```

```
        if (*entry != cur_entry) {
```

```
            XtQueryGeometry(*entry, NULL, &preferred);
```

```
            if (preferred.request_mode & CWWidth)
```

```
                width = preferred.width;
```

```
            else
```

```
                width = (*entry)->rectangle.width;
```

```
        }
```

```
    else
```

- 315 -

```

        width = (*entry)->rectangle.width;

        if ( width > widest )
            widest = width;
    }

    return(widest);
}

/*  Function Name: GetMenuHeight
 *  Description: Sets the length of the widest entry in pixels.
 *  Arguments: w - the simple menu widget.
 *  Returns: width of menu.
 */

static Dimension
GetMenuHeight(w)
Widget w;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject * entry;
    Dimension height;

    if (smw->simple_menu.menu_height)
        return(smw->core.height);

    height = smw->simple_menu.top_margin + smw->simple_menu.bottom_margin;

    if (smw->simple_menu.row_height == 0)
        ForAllChildren(smw, entry)
            if (XtIsManaged ((Widget) *entry))
                height += (*entry)->rectangle.height;

```

- 316 -

```
else
    height += smw->simple_menu.row_height * smw->composite.num_children;

return(height);
}
```

```
/*    Function Name: GetEventEntry
 *    Description: Gets an entry given an event that has X and Y coords.
 *    Arguments: w - the simple menu widget.
 *               event - the event.
 *    Returns: the entry that this point is in.
 */
```

```
static SmeObject
GetEventEntry(w, event)
Widget w;
XEvent * event;
{
    Position x_loc, y_loc;
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject * entry;

    switch (event->type) {
    case MotionNotify:
        x_loc = event->xmotion.x;
        y_loc = event->xmotion.y;
        break;
    case EnterNotify:
    case LeaveNotify:
        x_loc = event->xcrossing.x;
        y_loc = event->xcrossing.y;
        break;
```

- 317 -

```
case ButtonPress:
```

```
case ButtonRelease:
```

```
    x_loc = event->xbutton.x;
```

```
    y_loc = event->xbutton.y;
```

```
    break;
```

```
default:
```

```
    XtAppError(XtWidgetToApplicationContext(w),
```

```
                "Unknown event type in GetEventEntry().");
```

```
    break;
```

```
}
```

```
if ( (x_loc < 0) || (x_loc >= smw->core.width) || (y_loc < 0) ||
```

```
    (y_loc >= smw->core.height) )
```

```
    return(NULL);
```

```
ForAllChildren(smw, entry) {
```

```
    if (!XtIsManaged ((Widget) *entry)) continue;
```

```
    if ( ((*entry)->rectangle.y < y_loc) &&
```

```
        ((*entry)->rectangle.y + (*entry)->rectangle.height > y_loc) )
```

```
        if ( *entry == smw->simple_menu.label )
```

```
            return(NULL);      /* cannot select the label. */
```

```
        else
```

```
            return(*entry);
```

```
}
```

```
return(NULL);
```

```
}
```

- 318 -

## source/Select.c

```

/*
 * Selection from list widget
 *
 */

#include      "../include/xwave.h"

void  Select(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    Selection    sel=(Selection)closure;
    Widget      button=FindWidget(sel->button,w),
               shell=ShellWidget(sel->name,button,SW_below,NULL,NULL),
               form=FormatWidget("sel_form",shell), list_widget, widgets[3];
    String *list=(sel->list_proc)();
    FormItem     items[]={
        {"sel_cancel","close",0,0,FW_icon,NULL},
        {"sel_label",(String)sel->action_name,1,0,FW_label,NULL},
        {"sel_view",NULL,0,2,FW_view,NULL},
    };
    XtCallbackRec    list_calls[]={
        {Destroy,(caddr_t)shell},
        {sel->action_proc,sel->action_closure},
        {NULL,NULL},
    }, callbacks[]={

```

- 319 -

```
        {Destroy,(caddr_t)shell},
        {NULL,NULL},
    };
    Arg    args[1];

    FillForm(form,THREE,items,widgets,callbacks);
    XtSetArg(args[0],XtNlist,list);

list_widget=XtCreateManagedWidget("sel_list",listWidgetClass,widgets[2],args,ONE);
    XtAddCallbacks(list_widget,XtNcallback,list_calls);
    XtPopup(shell,XtGrabExclusive);
}
```

- 320 -

source/SmeBSBpr.c

#if ( !defined(lint) &amp;&amp; !defined(SABER) )

static char Xrcsid[] = "\$XConsortium: SmeBSB.c,v 1.9 89/12/13 15:42:48 kit Exp \$";

#endif

/\*

\* Copyright 1989 Massachusetts Institute of Technology

\*

\* Permission to use, copy, modify, distribute, and sell this software and its

\* documentation for any purpose is hereby granted without fee, provided that

\* the above copyright notice appear in all copies and that both that

\* copyright notice and this permission notice appear in supporting

\* documentation, and that the name of M.I.T. not be used in advertising or

\* publicity pertaining to distribution of the software without specific,

\* written prior permission. M.I.T. makes no representations about the

\* suitability of this software for any purpose. It is provided "as is"

\* without express or implied warranty.

\*

\* M.I.T. DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS SOFTWARE,  
INCLUDING ALL\* IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS, IN NO  
EVENT SHALL M.I.T.\* BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES  
OR ANY DAMAGES\* WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS,  
WHETHER IN AN ACTION\* OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS ACTION, ARISING OUT  
OF OR IN

\* CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.



- 321 -

\*/

/\*

\* SmeBSBpr.c - Source code file for BSB pull-right Menu Entry object.

\*

\*/

#include &lt;stdio.h&gt;

#include &lt;X11/IntrinsicP.h&gt;

#include &lt;X11/StringDefs.h&gt;

#include &lt;X11/Xmu/Drawing.h&gt;

#include &lt;X11/Xaw/XawInit.h&gt;

#include &lt;X11/Xaw/SimpleMenu.h&gt;

#include "SmeBSBprP.h"

#include &lt;X11/Xaw/Cardinals.h&gt;

#define ONE\_HUNDRED 100

#define offset(field) XtOffset(SmeBSBprObject, sme\_bsb.field)

static XtResource resources[] = {

{XtNlabel, XtCLabel, XtRString, sizeof(String),

offset(label), XtRString, NULL},

{XtNvertSpace, XtCVertSpace, XtRInt, sizeof(int),

offset(vert\_space), XtRImmediate, (caddr\_t) 25},

{XtNleftBitmap, XtCLeftBitmap, XtRPixmap, sizeof(Pixmap),

offset(left\_bitmap), XtRImmediate, (caddr\_t)None},

{XtNjustify, XtCJustify, XtRJustify, sizeof(XtJustify),

offset(justify), XtRImmediate, (caddr\_t) XtJustifyLeft},

{XtNrighthBitmap, XtCRightBitmap, XtRPixmap, sizeof(Pixmap),

- 322 -

```

        offset(right_bitmap), XtRImmediate, (caddr_t)None},
    {XtNleftMargin, XtCHorizontalMargins, XtRDimension, sizeof(Dimension),
        offset(left_margin), XtRImmediate, (caddr_t) 4},
    {XtNrightMargin, XtCHorizontalMargins, XtRDimension, sizeof(Dimension),
        offset(right_margin), XtRImmediate, (caddr_t) 4},
    {XtNforeground, XtCForeground, XtRPixel, sizeof(Pixel),
        offset(foreground), XtRString, "XtDefaultForeground"},
    {XtNfont, XtCFont, XtRFontStruct, sizeof(XFontStruct *),
        offset(font), XtRString, "XtDefaultFont"},
    {XtNmenuName, XtCMenuName, XtRString, sizeof(String),
        offset(menu_name), XtRString, (caddr_t)"menu"},
};
#undef offset

/*
 * Semi Public function definitions.
 */

static void Redisplay(), Destroy(), Initialize(), FlipColors(), PopupMenu();
static void ClassInitialize();
static Boolean SetValues();
static XtGeometryResult QueryGeometry();

/*
 * Private Function Definitions.
 */

static void GetDefaultSize(), DrawBitmaps(), GetBitmapInfo();
static void CreateGCs(), DestroyGCs();

#define superclass (&smeClassRec)
SmeBSBprClassRec smeBSBprClassRec = {

```

- 323 -

```
{
/* superclass      */ (WidgetClass) superclass,
/* class_name      */  "SmeBSBpr",
/* size            */  sizeof(SmeBSBprRec),
/* class_initializer */  ClassInitialize,
/* class_part_initialize*/ NULL,
/* Class init'ed    */  FALSE,
/* initialize       */  Initialize,
/* initialize_hook   */  NULL,
/* realize          */  NULL,
/* actions          */  NULL,
/* num_actions      */  ZERO,
/* resources        */  resources,
/* resource_count    */  XtNumber(resources),
/* xrm_class        */  NULLQUARK,
/* compress_motion   */  FALSE,
/* compress_exposure */  FALSE,
/* compress_enterleave*/  FALSE,
/* visible_interest */  FALSE,
/* destroy          */  Destroy,
/* resize           */  NULL,
/* expose           */  Redisplay,
/* set_values        */  SetValues,
/* set_values_hook   */  NULL,
/* set_values_almost */  XtInheritSetValuesAlmost,
/* get_values_hook   */  NULL,
/* accept_focus      */  NULL,
/* intrinsics version */  XtVersion,
/* callback offsets  */  NULL,
/* tm_table          */  NULL,
/* query_geometry     */  QueryGeometry,
/* display_accelerator*/  NULL,
```

- 324 -

```

    /* extension      */  NULL
}, {
    /* Menu Entry Fields */

    /* highlight */      FlipColors,
    /* unhighlight */    FlipColors,
    /* notify */        PopupMenu,
    /* extension      */  NULL
}, {
    /* BSB pull-right Menu entry Fields */

    /* extension      */  NULL
}
};

WidgetClass smeBSBprObjectClass = (WidgetClass) &smeBSBprClassRec;

/*****
 *
 * Semi-Public Functions.
 *
 *****/

/*      Function Name: ClassInitialize
 *      Description: Initializes the SmeBSBprObject.
 *      Arguments: none.
 *      Returns: none.
 */

static void
ClassInitialize()
{

```

- 325 -

```

XawInitializeWidgetSet();
XtAddConverter( XtRString, XtRJustify, XmuCvtStringToJustify, NULL, 0 );
}

/* Function Name: Initialize
 * Description: Initializes the simple menu widget
 * Arguments: request - the widget requested by the argument list.
 *            new      - the new widget with both resource and non
 *                      resource values.
 * Returns: none.
 */

/* ARGSUSED */
static void
Initialize(request, new)
Widget request, new;
{
    SmeBSBprObject entry = (SmeBSBprObject) new;

    if (entry->sme_bsb.label == NULL)
        entry->sme_bsb.label = XtName(new);
    else
        entry->sme_bsb.label = XtNewString( entry->sme_bsb.label );

    /* Xaw bug - bitmap initialization now performed */
    if (entry->sme_bsb.left_bitmap != None) GetBitmapInfo(entry, TRUE);
    if (entry->sme_bsb.right_bitmap != None) GetBitmapInfo(entry, FALSE);

    CreateGCs(new);
    GetDefaultSize(new, &(entry->rectangle.width), &(entry->rectangle.height));
}

```

- 326 -

```
/*    Function Name: Destroy
 *    Description: Called at destroy time, cleans up.
 *    Arguments: w - the simple menu widget.
 *    Returns: none.
 */
```

```
static void
Destroy(w)
Widget w;
{
    SmeBSBprObject entry = (SmeBSBprObject) w;

    DestroyGCs(w);
    if (entry->sme_bsb.label != XtName(w))
        XtFree(entry->sme_bsb.label);
}
```

```
/*    Function Name: Redisplay
 *    Description: Redisplays the contents of the widget.
 *    Arguments: w - the simple menu widget.
 *               event - the X event that caused this redisplay.
 *               region - the region the needs to be repainted.
 *    Returns: none.
 */
```

```
/* ARGSUSED */
static void
Redisplay(w, event, region)
Widget w;
XEvent * event;
Region region;
{
```

- 327 -

```
GC gc;
SmeBSBprObject entry = (SmeBSBprObject) w;
int font_ascent, font_descent, y_loc;

entry->sme_bsb.set_values_area_cleared = FALSE;
font_ascent = entry->sme_bsb.font->max_bounds.ascent;
font_descent = entry->sme_bsb.font->max_bounds.descent;

y_loc = entry->rectangle.y;

if (XtIsSensitive(w) && XtIsSensitive( XtParent(w) ) ) {
    if ( w == XawSimpleMenuGetActiveEntry(XtParent(w)) ) {
        XFillRectangle(XtDisplayOfObject(w), XtWindowOfObject(w),
            entry->sme_bsb.norm_gc, 0, y_loc,
            (unsigned int) entry->rectangle.width,
            (unsigned int) entry->rectangle.height);
        gc = entry->sme_bsb.rev_gc;
    }
    else
        gc = entry->sme_bsb.norm_gc;
}
else
    gc = entry->sme_bsb.norm_gray_gc;

if (entry->sme_bsb.label != NULL) {
    int x_loc = entry->sme_bsb.left_margin;
    int len = strlen(entry->sme_bsb.label);
    char * label = entry->sme_bsb.label;

    switch(entry->sme_bsb.justify) {
        int width, t_width;
```

- 328 -

```

case XtJustifyCenter:
    t_width = XTextWidth(entry->sme_bsb.font, label, len);
    width = entry->rectangle.width - (entry->sme_bsb.left_margin +
                                      entry->sme_bsb.right_margin);
    x_loc += (width - t_width)/2;
    break;
case XtJustifyRight:
    t_width = XTextWidth(entry->sme_bsb.font, label, len);
    x_loc = entry->rectangle.width - (entry->sme_bsb.right_margin +
                                      t_width);
    break;
case XtJustifyLeft:
default:
    break;
}

y_loc += (entry->rectangle.height -
          (font_ascent + font_descent)) / 2 + font_ascent;

XDrawString(XtDisplayOfObject(w), XtWindowOfObject(w), gc,
            x_loc, y_loc, label, len);
}

DrawBitmaps(w, gc);
}

/*  Function Name: SetValues
*   Description: Relayout the menu when one of the resources is changed.
*   Arguments: current - current state of the widget.
*              request - what was requested.
*              new - what the widget will become.

```



- 329 -

```
* Returns: none
```

```
*/
```

```
/* ARGSUSED */
```

```
static Boolean
```

```
SetValues(current, request, new)
```

```
Widget current, request, new;
```

```
{
```

```
    SmeBSBprObject entry = (SmeBSBprObject) new;
```

```
    SmeBSBprObject old_entry = (SmeBSBprObject) current;
```

```
    Boolean ret_val = FALSE;
```

```
    if (old_entry->sme_bsb.label != entry->sme_bsb.label) {
```

```
        if (old_entry->sme_bsb.label != XtName( new ) )
```

```
            XtFree( (char *) old_entry->sme_bsb.label );
```

```
        if (entry->sme_bsb.label != XtName(new) )
```

```
            entry->sme_bsb.label = XtNewString( entry->sme_bsb.label );
```

```
        ret_val = True;
```

```
    }
```

```
    if (entry->rectangle.sensitive != old_entry->rectangle.sensitive )
```

```
        ret_val = TRUE;
```

```
    if (entry->sme_bsb.left_bitmap != old_entry->sme_bsb.left_bitmap) {
```

```
        GetBitmapInfo(new, TRUE);
```

```
        ret_val = TRUE;
```

```
    }
```

```
    if (entry->sme_bsb.right_bitmap != old_entry->sme_bsb.right_bitmap) {
```

```
        GetBitmapInfo(new, FALSE);
```

- 330 -

```

    ret_val = TRUE;
}

if ( (old_entry->sme_bsb.font != entry->sme_bsb.font) ||
      (old_entry->sme_bsb.foreground != entry->sme_bsb.foreground) ) {
    DestroyGCs(current);
    CreateGCs(new);
    ret_val = TRUE;
}

if (ret_val) {
    GetDefaultSize(new,
                   &(entry->rectangle.width), &(entry->rectangle.height));
    entry->sme_bsb.set_values_area_cleared = TRUE;
}
return(ret_val);
}

/*  Function Name: QueryGeometry.
 *  Description: Returns the preferred geometry for this widget.
 *  Arguments: w - the menu entry object.
 *             intended, return_val - the intended and return geometry info.
 *  Returns: A Geometry Result.
 *
 *  See the Intrinsics manual for details on what this function is for.
 *
 *  I just return the height and width of the label plus the margins.
 */

```

```

static XtGeometryResult
QueryGeometry(w, intended, return_val)
Widget w;

```

- 331 -

```

XtWidgetGeometry *intended, *return_val;
{
    SmeBSBprObject entry = (SmeBSBprObject) w;
    Dimension width, height;
    XtGeometryResult ret_val = XtGeometryYes;
    XtGeometryMask mode = intended->request_mode;

    GetDefaultSize(w, &width, &height );

    if ( ((mode & CWWidth) && (intended->width != width)) ||
        !(mode & CWWidth) ) {
        return_val->request_mode |= CWWidth;
        return_val->width = width;
        ret_val = XtGeometryAlmost;
    }

    if ( ((mode & CWHeight) && (intended->height != height)) ||
        !(mode & CWHeight) ) {
        return_val->request_mode |= CWHeight;
        return_val->height = height;
        ret_val = XtGeometryAlmost;
    }

    if (ret_val == XtGeometryAlmost) {
        mode = return_val->request_mode;

        if ( ((mode & CWWidth) && (width == entry->rectangle.width)) &&
            ((mode & CWHeight) && (height == entry->rectangle.height)) )
            return(XtGeometryNo);
    }

    return(ret_val);

```

- 332 -

}

```

/*  Function Name: FlipColors
*   Description: Invert the colors of the current entry.
*   Arguments: w - the bsb menu entry widget.
*   Returns: none.
*/

```

static void

FlipColors(w)

Widget w;

{

```

    SmeBSBprObject entry = (SmeBSBprObject) w;

```

```

    if (entry->sme_bsb.set_values_area_cleared) return;

```

```

    XFillRectangle(XtDisplayOfObject(w), XtWindowOfObject(w),
                   entry->sme_bsb.invert_gc, 0, (int) entry->rectangle.y,
                   (unsigned int) entry->rectangle.width,
                   (unsigned int) entry->rectangle.height);

```

}

```

/*****
*
* Private Functions.
*
*****/

```

```

/*  Function Name: GetDefaultSize
*   Description: Calculates the Default (preferred) size of
*               this menu entry.
*   Arguments: w - the menu entry widget.

```

- 333 -

```

*           width, height - default sizes (RETURNED).
*   Returns: none.
*/

```

```
static void
```

```
GetDefaultSize(w, width, height)
```

```
Widget w;
```

```
Dimension * width, * height;
```

```
{
```

```
    SmeBSBprObject entry = (SmeBSBprObject) w;
```

```
    if (entry->sme_bsb.label == NULL)
```

```
        *width = 0;
```

```
    else
```

```
        *width = XTextWidth(entry->sme_bsb.font, entry->sme_bsb.label,
                           strlen(entry->sme_bsb.label));
```

```
    *width += entry->sme_bsb.left_margin + entry->sme_bsb.right_margin;
```

```
    *height = (entry->sme_bsb.font->max_bounds.ascent +
               entry->sme_bsb.font->max_bounds.descent);
```

```
    *height = (*height * ( ONE_HUNDRED +
                           entry->sme_bsb.vert_space )) / ONE_HUNDRED;
```

```
}
```

```
/*   Function Name: DrawBitmaps
```

```
*   Description: Draws left and right bitmaps.
```

```
*   Arguments: w - the simple menu widget.
```

```
*           gc - graphics context to use for drawing.
```

```
*   Returns: none
```

```
*/
```

- 334 -

```

static void
DrawBitmaps(w, gc)
Widget w;
GC gc;
{
    int x_loc, y_loc;
    SmeBSBprObject entry = (SmeBSBprObject) w;

    if ( (entry->sme_bsb.left_bitmap == None) &&
        (entry->sme_bsb.right_bitmap == None) ) return;

/*
 * Draw Left Bitmap.
 */

    y_loc = entry->rectangle.y + (entry->rectangle.height -
                                   entry->sme_bsb.left_bitmap_height) / 2;

    if (entry->sme_bsb.left_bitmap != None) {
        x_loc = (entry->sme_bsb.left_margin -
                 entry->sme_bsb.left_bitmap_width) / 2;
        XCopyPlane(XtDisplayOfObject(w), entry->sme_bsb.left_bitmap,
                   XtWindowOfObject(w), gc, 0, 0,
                   entry->sme_bsb.left_bitmap_width,
                   entry->sme_bsb.left_bitmap_height, x_loc, y_loc, 1);
    }

/*
 * Draw Right Bitmap.
 */

    y_loc = entry->rectangle.y + (entry->rectangle.height - /* Xaw bug - y_loc

```

- 335 -

calculated from right\_bitmap data \*/

entry->sme\_bsb.right\_bitmap\_height) / 2;

if (entry->sme\_bsb.right\_bitmap != None) {

x\_loc = entry->rectangle.width - (entry->sme\_bsb.right\_margin + /\* Xaw bug - +  
rather than - sign \*/

entry->sme\_bsb.right\_bitmap\_width) / 2;

XCopyPlane(XtDisplayOfObject(w), entry->sme\_bsb.right\_bitmap,

XtWindowOfObject(w), gc, 0, 0,

entry->sme\_bsb.right\_bitmap\_width,

entry->sme\_bsb.right\_bitmap\_height, x\_loc, y\_loc, 1);

}

}

/\* Function Name: GetBitmapInfo

\* Description: Gets the bitmap information from either of the bitmaps.

\* Arguments: w - the bsb menu entry widget.

\* is\_left - TRUE if we are testing left bitmap,

\* FALSE if we are testing the right bitmap.

\* Returns: none

\*/

static void

GetBitmapInfo(w, is\_left)

Widget w;

Boolean is\_left;

{

SmeBSBprObject entry = (SmeBSBprObject) w;

unsigned int depth, bw;

Window root;

int x, y;

unsigned int width, height;

- 336 -

```

char buf[BUFSIZ];

if (is_left) {
    if (entry->sme_bsb.left_bitmap != None) {
        if (!XGetGeometry(XtDisplayOfObject(w),
            entry->sme_bsb.left_bitmap, &root,
            &x, &y, &width, &height, &bw, &depth)) {
            sprintf(buf, "SmeBSB Object: %s %s \"%s\".", "Could not",
                "get Left Bitmap geometry information for menu entry ",
                XtName(w));
            XtAppError(XtWidgetToApplicationContext(w), buf);
        }
        if (depth != 1) {
            sprintf(buf, "SmeBSB Object: %s \"%s\"%s.",
                "Left Bitmap of entry ",
                XtName(w), " is not one bit deep.");
            XtAppError(XtWidgetToApplicationContext(w), buf);
        }
        entry->sme_bsb.left_bitmap_width = (Dimension) width;
        entry->sme_bsb.left_bitmap_height = (Dimension) height;
    }
}

else if (entry->sme_bsb.right_bitmap != None) {
    if (!XGetGeometry(XtDisplayOfObject(w),
        entry->sme_bsb.right_bitmap, &root,
        &x, &y, &width, &height, &bw, &depth)) {
        sprintf(buf, "SmeBSB Object: %s %s \"%s\".", "Could not",
            "get Right Bitmap geometry information for menu entry ",
            XtName(w));
        XtAppError(XtWidgetToApplicationContext(w), buf);
    }
    if (depth != 1) {

```



- 337 -

```

        sprintf(buf, "SmeBSB Object: %s \"%s\"%s.",
                "Right Bitmap of entry ", XtName(w),
                " is not one bit deep.");
        XtAppError(XtWidgetToApplicationContext(w), buf);
    }
    entry->sme_bsb.right_bitmap_width = (Dimension) width;
    entry->sme_bsb.right_bitmap_height = (Dimension) height;
}
}

```

```

/*  Function Name: CreateGCs
*   Description: Creates all gc's for the simple menu widget.
*   Arguments: w - the simple menu widget.
*   Returns: none.
*/

```

```
static void
```

```
CreateGCs(w)
```

```
Widget w;
```

```
{
```

```
    SmeBSBprObject entry = (SmeBSBprObject) w;
```

```
    XGCValues values;
```

```
    XtGCMask mask;
```

```
    values.foreground = XtParent(w)->core.background_pixel;
```

```
    values.background = entry->sme_bsb.foreground;
```

```
    values.font = entry->sme_bsb.font->fid;
```

```
    values.graphics_exposures = FALSE;
```

```
    mask      = GCForeground | GCBackground | GCFont | GCGraphicsExposures;
```

```
    entry->sme_bsb.rev_gc = XtGetGC(w, mask, &values);
```

```
    values.foreground = entry->sme_bsb.foreground;
```

- 338 -

```

values.background = XtParent(w)->core.background_pixel;
entry->sme_bsb.norm_gc = XtGetGC(w, mask, &values);

values.fill_style = FillTiled;
values.tile = XmuCreateStippledPixmap(XtScreenOfObject(w),
                                     entry->sme_bsb.foreground,
                                     XtParent(w)->core.background_pixel,
                                     XtParent(w)->core.depth);

values.graphics_exposures = FALSE;
mask |= GCTile | GCFillStyle;
entry->sme_bsb.norm_gray_gc = XtGetGC(w, mask, &values);

values.foreground ^= values.background;
values.background = 0;
values.function = GXxor;
mask = GCForeground | GCBackground | GCGraphicsExposures | GCFunction;
entry->sme_bsb.invert_gc = XtGetGC(w, mask, &values);
}

/*  Function Name: DestroyGCs
 *   Description: Removes all gc's for the simple menu widget.
 *   Arguments: w - the simple menu widget.
 *   Returns: none.
 */

static void
DestroyGCs(w)
Widget w;
{
    SmeBSBprObject entry = (SmeBSBprObject) w;

    XtReleaseGC(w, entry->sme_bsb.norm_gc);

```

- 339 -

```

    XtReleaseGC(w, entry->sme_bsb.norm_gray_gc);
    XtReleaseGC(w, entry->sme_bsb.rev_gc);
    XtReleaseGC(w, entry->sme_bsb.invert_gc);
}

#ifdef apollo

/*
 * The apollo compiler that we have optimizes out my code for
 * FlipColors() since it is static. and no one executes it in this
 * file. I am setting the function pointer into the class structure so
 * that it can be called by my parent who will tell me to when to
 * highlight and unhighlight.
 */

void _XawSmeBSBApolloHack ()
{
    FlipColors();
}

#endif /* apollo */

/* Hacked copy of PopupMenu from MenuButton widget to replace XtInheritNotify */

static void
PopupMenu(w, event, params, num_params)
Widget w;
XEvent * event;
String * params;
Cardinal * num_params;
{
    SmeBSBprObject mbw = (SmeBSBprObject) w;
    Widget menu, temp;

```

- 340 -

```
Arg arglist[2];
Cardinal num_args;
int menu_x, menu_y, menu_width, menu_height, button_width, button_height;
Position button_x, button_y;

temp = XtParent(w); /* Shell not menu entry is parent of menu */
while(temp != NULL) {
    menu = XtNameToWidget(temp, mbw->sme_bsb.menu_name);
    if (menu == NULL)
        temp = XtParent(temp);
    else
        break;
}

if (menu == NULL) {
    char error_buf[BUFSIZ];
    sprintf(error_buf, "MenuButton: %s %s.",
            "Could not find menu widget named", mbw->sme_bsb.menu_name);
    XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
    return;
}

if (!XtIsRealized(menu))
    XtRealizeWidget(menu);

menu_width = menu->core.width + 2 * menu->core.border_width;
button_width = w->core.width + 2 * w->core.border_width;
button_height = w->core.height + 2 * w->core.border_width;

menu_height = menu->core.height + 2 * menu->core.border_width;

XtTranslateCoords(w, 0, 0, &button_x, &button_y);
menu_x = button_x + button_width;
```

- 341 -

```
menu_y = button_y;

if (menu_x < 0)
    menu_x = 0;
else {
    int scr_width = WidthOfScreen(XtScreen(menu));
    if (menu_x + menu_width > scr_width)
        menu_x = scr_width - menu_width;
}

if (menu_y < 0)
    menu_y = 0;
else {
    int scr_height = HeightOfScreen(XtScreen(menu));
    if (menu_y + menu_height > scr_height)
        menu_y = scr_height - menu_height;
}

num_args = 0;
XtSetArg(arglist[num_args], XtNx, menu_x); num_args++;
XtSetArg(arglist[num_args], XtNy, menu_y); num_args++;
XtSetValues(menu, arglist, num_args);

XtPopupSpringLoaded(menu);
}
```

- 342 -

## source/Storage.c

```
/*  
    Routines to allow video frames to be stored in memory  
    or on disk: NewFrame, GetFrame, SaveFrame, FreeFrame, SaveHeader,  
    CopyHeader.  
*/
```

```
#include    "../include/xwave.h"
```

```
extern FILE *zropen();
```

```
extern void zseek();
```

```
extern void zclose();
```

```
void NewFrame(vid,number)
```

```
Video vid;
```

```
int number;
```

```
{
```

```
    if (vid->data[0][number] == NULL) {
```

```
        int channel, channels=vid->type == MONO?1:3;
```

```
        for(channel=0;channel < channels;channel++)
```

```
            vid->data[channel][number]=(short
```

```
            *)MALLOC(sizeof(short)*Size(vid,channel,0)*Size(vid,channel,1));
```

```
        }
```

```
}
```

```
void GetFrame(vid,number)
```

```
Video vid;
```

- 343 -

```

int    number;

{
    if (vid->data[0][number] == NULL) {
        char    file_name[STRLEN], *whole_frame;
        FILE    *fp, *fopen();
        int     pid, r, c, channel,
                start=vid->x_offset+vid->cols*vid->y_offset,

end=(vid->rows-vid->y_offset-vid->size[1])*vid->cols-vid->x_offset,
        inter=vid->cols-vid->size[0];

        NewFrame(vid,number);

        sprintf(file_name, "%s%s/%s!/%s%03d\0", global->home, IMAGE_DIR, vid->path, vid->files[0] == '\0'?vid->name:vid->files, number+vid->start);
        Dprintf("Reading file %s\n", file_name);
        fp=zopen(file_name, &pid);
        if (vid->precision == 0) whole_frame=(char
*)MALLOC(vid->rows*vid->cols);
        zseek(fp, vid->offset);
        for(channel=0; channel < (vid->type == MONO?1:3); channel++) {
            int    shift[2]={vid->type == YUV &&
channel!=0?vid->UVsample[0]:0, vid->type == YUV &&
channel!=0?vid->UVsample[1]:0};

            Dprintf("Reading channel %d\n", channel);
            if (vid->precision == 0) {

if(0 == fread(whole_frame, sizeof(char), (vid->cols >> shift[0])*(vid->rows >> shift[1]),
fp)) {

                Dprintf("Error whilst reading %s\n", file_name);

```

- 344 -

```

        Eprintf("Error whilst reading %s\n",file_name);
    }
    for(r=0;r<vid->size[1]>>shift[1];r++)
        for(c=0;c<vid->size[0]>>shift[0];c++) {
            short
            pel=cti(whole_frame[(vid->x_offset>>shift[0])+c+((vid->y_offset>>shift[1])+r)*
            vid->cols>>shift[0]]);

            vid->data[channel][number][c+r*(vid->size[0]>>shift[0])]=vid->negative?-1-pel:pel;
        }
    } else {
        if (start!=0) zseek(fp,start*sizeof(short));
        for(r=0;r<vid->size[1]>>shift[1];r++) {

            if(0==fread(&(vid->data[channel][number][r*(vid->size[0]>>shift[0])]),sizeof(short),
            vid->size[0]>>shift[0],fp)) {

                Dprintf("Error whilst reading

                %s\n",file_name);

                Eprintf("Error whilst reading

                %s\n",file_name);

            }
            if (inter!=0) zseek(fp,inter*sizeof(short));
            if (vid->negative)
                for(c=0;c<vid->size[0]>>shift[0];c++)

            vid->data[channel][number][c+r*(vid->size[0]>>shift[0])]=-1-vid->data[channel][nu
            mber][c+r*(vid->size[0]>>shift[0])];

```



- 345 -

source/Storage.c

```
/*  
    Routines to allow video frames to be stored in memory  
    or on disk: NewFrame, GetFrame, SaveFrame, FreeFrame, SaveHeader,  
    CopyHeader.  
*/
```

```
#include    "../include/xwave.h"
```

```
extern FILE *zropen();
```

```
extern void zseek();
```

```
extern void zclose();
```

```
void NewFrame(vid,number)
```

```
Video vid;
```

```
int number;
```

```
{
```

```
    if (vid->data[0][number] == NULL) {
```

```
        int channel, channels=vid->type==MONO?1:3;
```

```
        for(channel=0;channel<channels;channel++)
```

```
            vid->data[channel][number]=(short
```

```
            *)MALLOC(sizeof(short)*Size(vid,channel,0)*Size(vid,channel,1));
```

```
        }
```

```
}
```

```
void GetFrame(vid,number)
```

```
Video vid;
```

- 346 -

```

int    number;

{
    if (vid->data[0][number] == NULL) {
        char    file_name[STRLEN], *whole_frame;
        FILE    *fp, *fopen();
        int      pid, r, c, channel,
                start=vid->x_offset+vid->cols*vid->y_offset,

end=(vid->rows-vid->y_offset-vid->size[1])*vid->cols-vid->x_offset,
        inter=vid->cols-vid->size[0];

        NewFrame(vid,number);

        sprintf(file_name,"%s%s/%s/%s%03d\0",global->home,IMAGE_DIR,vid->path,vid->files[0] == '\0'?vid->name:vid->files,number+vid->start);
        Dprintf("Reading file %s\n",file_name);
        fp=zopen(file_name,&pid);
        if (vid->precision == 0) whole_frame=(char
*)MALLOC(vid->rows*vid->cols);
        zseek(fp,vid->offset);
        for(channel=0;channel<(vid->type == MONO?1:3);channel++) {
            int    shift[2]={vid->type == YUV &&
channel!=0?vid->UVsample[0]:0,vid->type == YUV &&
channel!=0?vid->UVsample[1]:0};

            Dprintf("Reading channel %d\n",channel);
            if (vid->precision == 0) {

if(0 == fread(whole_frame,sizeof(char),(vid->cols >> shift[0])*(vid->rows >> shift[1]),
fp)) {

                Dprintf("Error whilst reading %s\n",file_name);

```

- 347 -

```

        Eprintf("Error whilst reading %s\n",file_name);
    }
    for(r=0;r<vid->size[1]>>shift[1];r++)
        for(c=0;c<vid->size[0]>>shift[0];c++) {
            short
            pel=cti(whole_frame[(vid->x_offset>>shift[0])+c+((vid->y_offset>>shift[1])+r)*
            (vid->cols>>shift[0])]);

            vid->data[channel][number][c+r*(vid->size[0]>>shift[0])]=vid->negative?-1-pel:pel;
        }
    } else {
        if (start!=0) zseek(fp,start*sizeof(short));
        for(r=0;r<vid->size[1]>>shift[1];r++) {

            if(0==fread(&(vid->data[channel][number][r*(vid->size[0]>>shift[0])]),sizeof(short),
            vid->size[0]>>shift[0],fp)) {

                Dprintf("Error whilst reading

                %s\n",file_name);

                Eprintf("Error whilst reading

                %s\n",file_name);

            }
            if (inter!=0) zseek(fp,inter*sizeof(short));
            if (vid->negative)
                for(c=0;c<vid->size[0]>>shift[0];c++)

            vid->data[channel][number][c+r*(vid->size[0]>>shift[0])]=-1-vid->data[channel][nu
            mber][c+r*(vid->size[0]>>shift[0])];

```

- 348 -

}

```
void SaveHeader(vid)
```

```
Video vid;
```

{

```
FILE *fp, *fopen();
```

```
char file_name[STRLEN];
```

```
String types[]={"MONO","RGB","YUV"};
```

```
Dprintf("SaveHeader %s\n",vid->name);
```

```
sprintf(file_name,"%s%s/%s%s\0",global->home,VID_DIR,vid->name,VID_EXT);
```

```
fp=fopen(file_name,"w");
```

```
fprintf(fp,"Path \" %s\" \n",vid->path);
```

```
if (vid->files[0]!='\0') fprintf(fp,"Files \" %s\" \n",vid->files);
```

```
if (vid->type==YUV) fprintf(fp,"Type %s %d
```

```
%d\n",types[vid->type],vid->UVsample[0],vid->UVsample[1]);
```

```
else fprintf(fp,"Type %s\n",types[vid->type]);
```

```
if (vid->rate!=0) fprintf(fp,"Rate %d\n",vid->rate);
```

```
if (vid->disk) fprintf(fp,"Disk\n");
```

```
if (vid->gamma) fprintf(fp,"Gamma\n");
```

```
fprintf(fp,"Start %03d\n",vid->start);
```

```
fprintf(fp,"Length %d\n",vid->size[2]);
```

```
fprintf(fp,"Dimensions %d %d\n",vid->cols,vid->rows);
```

```
switch(vid->trans.type) {
```

```
case TRANS_None: fprintf(fp,"Transform None\n"); break;
```

```
case TRANS_Wave: fprintf(fp,"Transform Wavelet %d %d
```

```
%s\n",vid->trans.wavelet.space[0],vid->trans.wavelet.space[1],vid->trans.wavelet.dirn
```

```
?"Yes":"No"); break;
```

- 349 -

```

    }
    fprintf(fp, "Header %d\n", vid->offset);
    fprintf(fp, "Offsets %d %d\n", vid->x_offset, vid->y_offset);
    fprintf(fp, "Size %d %d\n", vid->size[0], vid->size[1]);
    fprintf(fp, "Precision %d\n", vid->precision);
    fclose(fp);
}

```

Video CopyHeader(src)

Video src;

```

{
    Video dst=(Video)MALLOC(sizeof(VideoRec));
    int    channel;

    Dprintf("CopyHeader %s\n",src);
    strcpy(dst->path,src->path);
    strcpy(dst->name,src->name);
    dst->type=src->type;
    dst->disk=src->disk;
    dst->gamma=src->gamma;
    dst->negative=False;
    dst->rate=src->rate;
    dst->start=src->start;
    dst->size[0]=src->size[0];
    dst->size[1]=src->size[1];
    dst->size[2]=src->size[2];
    dst->UVsample[0]=src->UVsample[0];
    dst->UVsample[1]=src->UVsample[1];
    dst->offset=0;
    dst->cols=src->size[0];
}

```

- 350 -

```
dst->rows=src->size[1];
dst->x_offset=0;
dst->y_offset=0;
dst->trans=src->trans;
dst->precision=src->precision;
for(channel=0;channel<(src->type==MONO?1:3);channel++)
    dst->data[channel]=(short **)MALLOC(src->size[2]*sizeof(short *));
return(dst);
}
```

- 351 -

source/Transform.c

```
/*
    Transform video using wavelet transform
*/

#include    "xwave.h"
#include    "Transform.h"
extern short Round();

void DropVideo(w,closure,call_data)

Widget      w;
caddr_t      closure, call_data;

{
    Video video=global->videos->next;
    int    frame, channel;

    for(channel=0;channel < (global->videos->type == MONO?1:(global->videos->type == YUV?3:4));channel++)
        if (global->videos->data[channel] != NULL) {
            for (frame=0;frame < global->videos->size[2];frame++)
                if (global->videos->data[channel][frame] != NULL)
                    XtFree(global->videos->data[channel][frame]);
            XtFree(global->videos->data[channel]);
        }
    XtFree(global->videos);
    global->videos=video;
}
```

- 352 -

}

```
void ChangePrecision(src,dst,frame,old,new)
```

```
Video src, dst;
```

```
int frame, old, new;
```

{

```
int channel, i;
```

```
if(src!=dst || old!=new) {
```

```
int shift=new-old;
```

```
Dprintf("Changing precision %d to %d for frame %d\n",old,new,frame);
```

```
for (channel=0;channel<(src->type==MONO?1:3);channel++) {
```

```
int size=Size(src,channel,0)*Size(src,channel,1);
```

```
for(i=0;i<size;i++)
```

```
dst->data[channel][frame][i]=shift<0?Round(src->data[channel][frame][i],-shift):(shift
==0?src->data[channel][frame][i]:src->data[channel][frame][i]<<shift);
```

```
}
```

```
}
```

}

```
void TransformCtrl(w,closure,call_data)
```

```
Widget w;
```

```
caddr_t closure, call_data;
```

{

```
TransCtrl ctrl=(TransCtrl)closure;
```



- 353 -

```

Video src=ctrl->src, dst=CopyHeader(src);
long i, frame, channel;

Dprintf("TransformCtrl\n");
strcpy(dst->name,ctrl->name);
dst->trans.type=TRANS_Wave;
dst->trans.wavelet.space[0]=ctrl->space[0];
dst->trans.wavelet.space[1]=ctrl->space[1];
dst->trans.wavelet.dirn=ctrl->dirn;
dst->precision=ctrl->precision;
strcpy(dst->files,dst->name);
if (dst->disk) SaveHeader(dst);
if (src->trans.type!=TRANS_Wave) {
    src->trans.type=TRANS_Wave;
    src->trans.wavelet.space[0]=0;
    src->trans.wavelet.space[1]=0;
}

if (src->trans.wavelet.space[0]!=dst->trans.wavelet.space[0] ||
src->trans.wavelet.space[1]!=dst->trans.wavelet.space[1])
    for(frame=0;frame<dst->size[2];frame++) {
        int
max_precision=src->precision>dst->precision?src->precision:dst->precision;

        Dprintf("Processing frame %d\n",frame);
        NewFrame(dst,frame);
        GetFrame(src,frame);
        ChangePrecision(src,dst,frame,src->precision,max_precision);
        for (channel=0;channel<(src->type==MONO?1:3);channel++)
        {
            int oct_src=src->trans.wavelet.space[channel==0?0:1],

```

- 354 -

```
oct_dst=dst->trans.wavelet.space[channel==0?0:1],
```

```
size[2]={Size(dst,channel,0),Size(dst,channel,1)};
```

```
    if (oct_src!=oct_dst)
```

```
    Convolve(dst->data[channel][frame],ctrl->dim,size,oct_src,oct_dst);
```

```
    }
```

```
    ChangePrecision(dst,dst,frame,max_precision,dst->precision);
```

```
    SaveFrame(dst,frame);
```

```
    FreeFrame(dst,frame);
```

```
    FreeFrame(src,frame);
```

```
    }
```

```
    if (src->trans.wavelet.space[0]==0 && src->trans.wavelet.space[1]==0)
```

```
src->trans.type=TRANS_None;
```

```
    if (dst->trans.wavelet.space[0]==0 && dst->trans.wavelet.space[1]==0) {
```

```
        dst->trans.type=TRANS_None;
```

```
        if (dst->disk) SaveHeader(dst);
```

```
    }
```

```
    dst->next=global->videos;
```

```
    global->videos=dst;
```

```
}
```

```
void Transtype(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
    Video vid=(Video)closure;
```

```
    if (vid->trans.wavelet.space[0]==0 && vid->trans.wavelet.space[1]==0)
```

- 355 -

```
vid->trans.type=TRANS_None;
}
```

```
void BatchTransCtrl(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
    TransCtrl  ctrl=(TransCtrl)closure;

    if (ctrl->src==NULL) ctrl->src=FindVideo(ctrl->src_name,global->videos);
    if (ctrl->src->trans.type==TRANS_Wave)
ctrl->dirn=ctrl->src->trans.wavelet.dirn;
    TransformCtrl(w,closure,call_data);
}
```

```
TransCtrl  InitTransCtrl(name)
```

```
String name;
```

```
{
    TransCtrl  ctrl=(TransCtrl)MALLOC(sizeof(TransCtrlRec));

    strcpy(ctrl->src_name,name);
    strcpy(ctrl->name,name);
    ctrl->dirn=False;
    Dprintf("Transform\n");
    return(ctrl);
}
```

```
#define TRANS_ICONS 16
```

- 356 -

```
void Transform(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
    Video video=(Video)closure;
```

```
    TransCtrl ctrl=InitTransCtrl(video->name);
```

```
    NumInput  spaceInput=(NumInput)MALLOC(2*sizeof(NumInputRec)),
```

```
              precInput=(NumInput)MALLOC(sizeof(NumInputRec));
```

```
    Message   msg=NewMessage(ctrl->name,NAME_LEN);
```

```
    XtCallbackRec destroy_call[]={
```

```
        {Free,(caddr_t)ctrl},
```

```
        {Free,(caddr_t)spaceInput},
```

```
        {Free,(caddr_t)precInput},
```

```
        {CloseMessage,(caddr_t)msg},
```

```
        {NULL,NULL},
```

```
    };
```

```
    Widget     parent=FindWidget("frm_transform",XtParent(w)),
```

```
    shell=ShellWidget("transform",parent,SW_below,NULL,destroy_call),
```

```
        form=FormatWidget("trans_form",shell),
```

```
    widgets[TRANS_ICONS];
```

```
    FormItem   items[]={
```

```
        {"trans_cancel","cancel",0,0,FW_icon,NULL},
```

```
        {"trans_confirm","confirm",1,0,FW_icon,NULL},
```

```
        {"trans_title","Transform a video",2,0,FW_label,NULL},
```

```
        {"trans_vid_lab","Video Name:",0,3,FW_label,NULL},
```

```
        {"trans_video",NULL,4,3,FW_text,(String)msg},
```

```
        {"trans_dirn_lab","Direction:",0,4,FW_label,NULL},
```

```
        {"trans_dirn",NULL,4,4,FW_yn,(String)&ctrl->dirn},
```

- 357 -

```

    {"trans_bits_int",NULL,0,6,FW_integer,(String)precInput},
    {"trans_bits_down",NULL,4,6,FW_down,(String)precInput},
    {"trans_bits_up",NULL,9,6,FW_up,(String)precInput},

    {"trans_spc0_int",NULL,0,8,FW_integer,(String)&spaceInput[0]},
    {"trans_spc0_down",NULL,4,8,FW_down,(String)&spaceInput[0]},
    {"trans_spc0_up",NULL,12,8,FW_up,(String)&spaceInput[0]},
    {"trans_spc1_int",NULL,0,11,FW_integer,(String)&spaceInput[1]},
    {"trans_spc1_down",NULL,4,11,FW_down,(String)&spaceInput[1]},

    {"trans_spc1_up",NULL,15,11,FW_up,(String)&spaceInput[1]},
};

XtCallbackRec      callbacks[] = {
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {TransformCtrl,(caddr_t)ctrl},
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {ChangeYN,(caddr_t)&ctrl->dirn}, {NULL,NULL},
    {NumIncDec,(caddr_t)precInput}, {NULL,NULL},
    {NumIncDec,(caddr_t)precInput}, {NULL,NULL},
    {NumIncDec,(caddr_t)&spaceInput[0]}, {NULL,NULL},
    {NumIncDec,(caddr_t)&spaceInput[0]}, {NULL,NULL},
    {NumIncDec,(caddr_t)&spaceInput[1]}, {NULL,NULL},
    {NumIncDec,(caddr_t)&spaceInput[1]}, {NULL,NULL},
};

Dprintf("Transform\n");
msg->rows=1; msg->cols=NAME_LEN;
ctrl->src=video;
if (video->trans.type==TRANS_Wave) {
    ctrl->space[0]=video->trans.wavelet.space[0];

```

- 358 -

```

    ctrl->space[1]=video->trans.wavelet.space[1];
    ctrl->dirn=video->trans.wavelet.dirn;
} else {
    ctrl->space[0]=0; ctrl->space[1]=0;
    ctrl->dirn=False;
}
ctrl->precision=video->precision;

spaceInput[0].format=video->type==YUV?"Y-Space: %d":"Space: %d";
spaceInput[0].max=100;
spaceInput[0].min=0;
spaceInput[0].value=&ctrl->space[0];
if (video->type==YUV) {
    spaceInput[1].format="UV-Space: %d";
    spaceInput[1].max=100;
    spaceInput[1].min=0;
    spaceInput[1].value=&ctrl->space[1];
}
precInput->format="Precision: %d";
precInput->max=16;
precInput->min=0;
precInput->value=&ctrl->precision;

```

```

FillForm(form,TRANS_ICONS-(video->type==YUV?0:3),items,widgets,callbacks);
if (video->trans.type==TRANS_Wave) XtSetSensitive(widgets[6],False);
XtPopup(shell,XtGrabExclusive);
}

```

- 359 -

## source/Update.c

```
/*
    Update Image, Info and InfoText from positional information
*/

#include    "../include/xwave.h"
#include    <varargs.h>
extern int  CompositePixel();
extern int  Dither();
extern short Round();
extern int  ReMap();
extern Palette FindPalette();

char  *ResizeData(size)

int    size;

{
    static char    *data=NULL;
    static int     data_size=0;

    if (size!=data_size) {
        Dprintf("New frame memory\n");
        if (data!=NULL) XtFree(data);
        data=(char *)MALLOC(size);
        data_size=size;
    }
    return(data);
}
```

- 360 -

```

Pixmap      UpdateImage(frame)

Frame frame;

{
    int      x, y, i;
    Display      *dpy=XtDisplay(global->toplevel);
    void  CvtIndex(), UpdatePoint();
    Palette      pal=FindPalette(global->palettes,frame->palette);
    Video  vid=frame->video;
    int      scrn=XDefaultScreen(dpy), depth=DisplayPlanes(dpy,scrn),
            size[2]={Size(vid,frame->channel,0),Size(vid,frame->channel,1)},
            img_size[2]={size[0]<<frame->zoom,size[1]<<frame->zoom},
            bpl=(img_size[0]*depth+7)/8, new_size=img_size[1]*bpl,
            space=vid->trans.wavelet.space[vid->type]==YUV &&
frame->channel!=0 && frame->channel!=3?1:0];
    char      *data=ResizeData(new_size);
    XImage
    *image=XCreateImage(dpy,global->visinfo->visual,depth,ZPixmap,0,data,img_size[0],i
mg_size[1],8,bpl);
    Pixmap
    pixmap=XCreatePixmap(dpy,DefaultRootWindow(dpy),img_size[0],img_size[1],depth);

    Dprintf("UpdateImage\n");
    if (global->levels==2 && frame->channel==3) frame->channel=0;
    for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {
        int      data_x=x, data_y=y, off_x, off_y, oct;

        if (vid->trans.type==TRANS_Wave)
CvtIndex(x,y,size[0],size[1],space,&data_x,&data_y,&oct);
        for(off_x=0;off_x<1<<frame->zoom;off_x++)
            for(off_y=0;off_y<1<<frame->zoom;off_y++) {

```



- 361 -

```

        int    img_x=off_x+(x<<frame->zoom),
img_y=off_y+(y<<frame->zoom),

pix=CompositePixel(frame,data_x,data_y,img_x,img_y);

XPutPixel(image,img_x,img_y,ReMap(pix,global->levels,pal));
    }
}

XPutImage(dpy,pixmap,DefaultGC(dpy,scrn),image,0,0,0,0,img_size[0],img_size[1]);
    if (frame->point_switch==True) UpdatePoint(dpy,frame,pixmap);
    XtFree(image);
    return(pixmap);
}

void  CvtIndex(x,y,max_x,max_y,oct,ret_x,ret_y,ret_oct)

int    x, y, max_x, max_y, oct, *ret_x, *ret_y, *ret_oct;

{
    Boolean    hgx=x>=(max_x>>1), hgy=y>=(max_y>>1);

    *ret_x=hgx?x-(max_x>>1):x;
    *ret_y=hgy?y-(max_y>>1):y;
    if (!hgx && !hgy && oct>1) {

CvtIndex(*ret_x,*ret_y,max_x>>1,max_y>>1,oct-1,ret_x,ret_y,ret_oct);
        *ret_x= *ret_x<<1;
        *ret_y= *ret_y<<1;
        *ret_oct+=1;
    } else {

```

- 362 -

```

        *ret_x = (*ret_x < 1) + hgx;
        *ret_y = (*ret_y < 1) + hgy;
        *ret_oct = hgx || hgy ? 0 : 1;
    }
}

void UpdateInfo(frame)

Frame frame;

{
    Message    msg = frame->msg;
    Video  vid = frame->video;
    int      *locn = frame->point->location, posn[2] = {locn[0], locn[1]},
            channel = 3 == frame->channel ? 0 : frame->channel,
width = Size(vid, channel, 0);
    short  *data = vid->data[channel][frame->frame];

    msg->info.ptr[0] = '\0';
    msg->info.length = 0;
    if (vid->type == YUV && channel != 0) {
        posn[0] = posn[0] >> vid->UVsample[0];
        posn[1] = posn[1] >> vid->UVsample[1];
    }
    if (vid->trans.type != TRANS_Wave)
        Mprintf(msg, "Point  : x = %03d y = %03d t = %03d
c = %4d", locn[0], locn[1], frame->frame + vid->start, data[posn[0] + Size(vid, channel, 0) * po
sn[1]]);
    else {
        int      octs = vid->trans.wavelet.space[vid->type == YUV &&
channel != 0 ? 1 : 0],
X, Y, oct, sub,

```

- 363 -

```
blkDC[2] = {(posn[0] > > octs)&-2, (posn[1] > > octs)&-2},
```

```
offDC[2] = {(posn[0] > > octs)&1, (posn[1] > > octs)&1};
```

```
Mprintf(msg, "Point : f= %03d x= %03d
```

```
y= %03d\n", frame->frame+vid->start, locn[0], locn[1]);
```

```
Mprintf(msg, "Low pass: x= %03d y= %03d\n", blkDC[0], blkDC[1]);
```

```
for(Y=0; Y<2; Y++) {
```

```
    for(X=0; X<2; X++)
```

```
Mprintf(msg, "%4d%c", data[Access(blkDC[0]+X, blkDC[1]+Y, octs-1, 0, width)], X==off
DC[0] && Y==offDC[1]?'*':' ');
```

```
Mprintf(msg, "\n");
```

```
}
```

```
for(oct=octs; oct>0; oct--) {
```

```
    int    blk[2] = {(posn[0] > > oct)&-2, (posn[1] > > oct)&-2},
```

```
            off[2] = {(posn[0] > > oct)&1, (posn[1] > > oct)&1};
```

```
Mprintf(msg, "Oct : %d\n", oct);
```

```
for(Y=0; Y<2; Y++) {
```

```
    for(sub=1; sub<4; sub++) {
```

```
        for(X=0; X<2; X++) {
```

```
Mprintf(msg, "%4d%c", data[Access(blk[0]+X, blk[1]+Y, oct-1, sub, width)], X==off[0]
&& Y==off[1]?'*':' ');
```

```
        }
```

```
        if (sub<3) Mprintf(msg, " ");
```

```
    }
```

```
    if (oct!=0 || Y==0) Mprintf(msg, "\n");
```

```
}
```

```
}
```

```
}
```

- 364 -

```
Mflush(msg);
}

/*  Function Name:    CrossHair
 *  Description:    Draws cross-hair on pixmap
 *  Arguments:    dpy - Xserver display
 *                pixmap - pixmap to draw on
 *                gc - GC to draw with
 *                x_off, y_off - offset into pixmap
 *                width, height - size of box containing cross-hair
 *                x, y - coordinates within box
 *                zoom - scaling factor
 *  Returns:        alters pixmap.
 */
```

```
void CrossHair(dpy,pixmap,gc,x_off,y_off,width,height,x,y,zoom)
```

```
Display    *dpy;
Pixmap     pixmap;
GC         gc;
int        x_off, y_off, width, height, x, y, zoom;

{
    int      xtra=Shift(1,zoom);

    x_off=Shift(x_off,zoom);
    y_off=Shift(y_off,zoom);
    width=Shift(width,zoom);
    height=Shift(height,zoom);
    x=Shift(x,zoom);
    y=Shift(y,zoom);
```

- 365 -

```

XFillRectangle(dpy,pixmap,gc,x+x_off+xtra/2,y_off,1,y); /* North hair */
XFillRectangle(dpy,pixmap,gc,x_off,y+y_off+xtra/2,x,1); /* West hair */
XFillRectangle(dpy,pixmap,gc,x+x_off+xtra/2,y+y_off+xtra,1,height-y-xtra); /*
South hair */
XFillRectangle(dpy,pixmap,gc,x+x_off+xtra,y+y_off+xtra/2,width-x-1,1); /*
East hair */
}

```

```

/*      Function Name:      UpdatePoint
*      Description:  Draws cross-hair on image at frame->location
*      Arguments:   dpy - X server display
*                  frame - Frame supplying drawing parameters
*                  pixmap - X pixmap to draw on
*      Returns:      alters pixmap.
*/

```

```

void  UpdatePoint(dpy,frame,pixmap)

```

```

Display      *dpy;

```

```

Frame frame;

```

```

Pixmap      pixmap;

```

```

{

```

```

    unsigned long      gcmask;

```

```

    XGCValues  gcvals;

```

```

    GC      gc;

```

```

    Video  vid=frame->video;

```

```

    int    posn[2]={frame->point->location[0],frame->point->location[1]},

```

```

    channel=3==frame->channel?0:frame->channel;

```

```

    gcvals.function=GXEquiv;

```

```

    gcmask=GCFFunction;

```

- 366 -

```

gcvals.foreground = 127;
gcmask = gcmask | GCForeground;
gc = XCreateGC(dpy, pixmap, gcmask, &gcvals);
if (vid->type == YUV && channel != 0) {
    posn[0] = posn[0] >> vid->UVsample[0];
    posn[1] = posn[1] >> vid->UVsample[1];
}
if (vid->trans.type != TRANS_Wave) {

CrossHair(dpy, pixmap, gc, 0, 0, Size(vid, channel, 0), Size(vid, channel, 1), posn[0], posn[1], fra
me->zoom);
    } else {
        int    octs = vid->trans.wavelet.space[vid->type == YUV &&
channel != 0 ? 1 : 0], oct,

                size[2] = {Size(vid, channel, 0), Size(vid, channel, 1)};

CrossHair(dpy, pixmap, gc, 0, 0, size[0], size[1], posn[0], posn[1], frame->zoom-octs);
        for(oct = 1; oct <= octs; oct++) {

CrossHair(dpy, pixmap, gc, size[0], 0, size[0], size[1], posn[0], posn[1], frame->zoom-oct);

CrossHair(dpy, pixmap, gc, 0, size[1], size[0], size[1], posn[0], posn[1], frame->zoom-oct);

CrossHair(dpy, pixmap, gc, size[0], size[1], size[0], size[1], posn[0], posn[1], frame->zoom-oct
);
        }
    }
XFreeGC(dpy, gc);
}

```

- 367 -

## source/Video2.c

```
/*
    Video callback routines for Listing, Loading
*/

#include    "../include/xwave.h"
#include    "../include/ImageHeader.h"
#include    "../include/DTheader.h"
#include    "Video.h"
#include    <sys/time.h>
extern void EraseFrame();
extern void CvtIndex();

void SortList(list,no)

String list[];
int    no;

{
    int    i, j, k;

    if (no > 1) for(i=1;i<no;i++) for(j=0;j<i;j++) {
        k=0;
        while(list[i][k]==list[j][k] && list[i][k]!='\0' && list[j][k]!='\0') k++;
        if (list[i][k]<list[j][k]) {
            String spare=list[i];

            list[i]=list[j];
            list[j]=spare;
        }
    }
}
```

- 368 -

```

    }
}

```

```
String *ReadDirectory(dir_path,extension)
```

```
String dir_path, extension;
```

```
{
```

```
    DIR *dirp, *opendir();
```

```
    struct dirent *dp, *readdir();
```

```
    static String *fileList=NULL, file;
```

```
    int count=0, i;
```

```
    char path[STRLEN];
```

```
    Dprintf("ReadDirectory for %s extension\n",extension);
```

```
    if (fileList!=NULL) {
```

```
        for(i=0;NULL!=fileList[i];i++) free(fileList[i]);
```

```
        free(fileList);
```

```
    }
```

```
    fileList=(String *)MALLOC(sizeof(String *)*300);
```

```
    sprintf(path,"%s%s\0",global->home,dir_path);
```

```
    dirp=fopen(path);
```

```
    for (dp=readdir(dirp);dp!=NULL && count<299;dp=readdir(dirp)) {
```

```
        int length=strlen(dp->d_name);
```

```
        if (length>=strlen(extension))
```

```
        if (!strcmp(dp->d_name+length-strlen(extension),extension)) {
```

```
            Dprintf("Found %s in dir\n",dp->d_name);
```

```
            fileList[count]=(char *)MALLOC(length+1);
```

```
            strncpy(fileList[count],dp->d_name,length-strlen(extension));
```

```
            count+=1;
```

```
        }
```



- 369 -

```
    }  
    fileList[count]=NULL;  
    SortList(fileList,count);  
    closedir(dirp);  
    return(fileList);  
}
```

```
int    Shift(value,shift)
```

```
int    value, shift;
```

```
{  
    if (shift ==0) return value;  
    else if (shift <0) return(value >> -shift);  
    else return(value << shift);  
}
```

```
int    Size(video,channel,dimension)
```

```
Video video;
```

```
int    channel, dimension;
```

```
{  
    if (video->type ==YUV && dimension!=2 && channel!=0 && channel!=3)  
return(video->size[dimension] >> video->UVsample[dimension]);  
    else return(video->size[dimension]);  
}
```

```
int    Address2(video,channel,x,y)
```

```
Video video;
```

```
int    channel, x, y;
```

- 370 -

```
{
    if (video->type == YUV && channel != 0 && channel != 3)
return(x + Size(video,channel,0)*y);
    else return(x + video->size[0]*y);
}

int    Address(video,channel,x,y)

Video video;
int    channel, x, y;

{
    if (video->type == YUV && channel != 0 && channel != 3)
return((x >> video->UVsample[0]) + Size(video,channel,0)*(y >> video->UVsample[1])
);
    else return(x + video->size[0]*y);
}

String *VideoList()

{
    Dprintf("VideoList\n");
    return(ReadDirectory(VID_DIR,VID_EXT));
}

String *KlicsList()

{
    Dprintf("KlicsList\n");
    return(ReadDirectory(KLICS_DIR,KLICS_EXT));
}
```

- 371 -

```
String *KlicsListSA()
```

```
{
    Dprintf("KlicsListSA\n");
    return(ReadDirectory(KLICS_SA_DIR,KLICS_SA_EXT));
}
```

```
String *VideoCurrentList()
```

```
{
    static String videoList[300];
    Video video=global->videos;
    int count=0;

    Dprintf("VideoCurrentList\n");
    while (video!=NULL) {
        if (count==300) Dprintf("VideoCurrentList: static size exceeded\n");
        videoList[count]=video->name;
        video=video->next;
        count+=1;
    }
    videoList[count]=NULL;
    SortList(videoList,count);
    return(videoList);
}
```

```
String *VideoYUVList()
```

```
{
    static String videoList[300];
    Video video=global->videos;
    int count=0;
```

- 372 -

```

Dprintf("VideoCurrentList\n");
while (video!=NULL) {
    if (count==300) Dprintf("VideoYUVList: static size exceeded\n");
    if (video->type==YUV) videoList[count++] = video->name;
    video=video->next;
}
videoList[count]=NULL;
SortList(videoList,count);
return(videoList);
}

```

```
String *VideoDropList()
```

```

{
    static String videoList[300];
    Video video=global->videos;
    int count=0;
    Boolean VideoHasFrame();

    Dprintf("VideoDropList\n");
    while (video!=NULL) {
        if (False==VideoHasFrame(video,global->frames)) {
            videoList[count]=video->name;
            count+=1;
        };
        video=video->next;
    }
    videoList[count]=NULL;
    SortList(videoList,count);
    return(videoList);
}

```

- 373 -

Boolean      VideoHasFrame(video,frame)

Video video;

Frame frame;

```
{
    if (frame==NULL) return(False);
    else if (frame->video==video) return(True);
        else return(VideoHasFrame(video,frame->next));
}
```

void    VideoLoad(w,closure,call\_data)

Widget      w;

caddr\_t      closure, call\_data;

```
{
    Video vid=(Video)MALLOC(sizeof(VideoRec));
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
    int    frame, channel;

    Dprintf("VideoLoad %s\n",name->string);
    strcpy(vid->name,name->string);
    strcpy(vid->files,name->string);
    vid->next=global->videos;
    global->videos=vid;
    vid->rate=30;
    Parse(VID_DIR,name->string,VID_EXT);
    for (channel=0;channel<(vid->type==MONO?1:3);channel++)
        vid->data[channel]=(short **)MALLOC(sizeof(short *)*vid->size[2]);
    if (!vid->disk) for(frame=0;frame<vid->size[2];frame++)
        GetFrame(vid,frame);
}
```

- 374 -

```

    Dprintf("VideoLoad terminated\n");
    if (global->batch == NULL) InitFrame(w,closure,call_data);
}

void VideoSave(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    Video video;
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
    int      frame;

    video=FindVideo(name->string,global->videos);
    if (video->files[0] == '\0') strcpy(video->files,name->string);
    SaveHeader(video);
    for (frame=0;frame<video->size[2];frame++) {
        Boolean      disk=video->disk;

        GetFrame(video,frame);
        video->disk=True;
        SaveFrame(video,frame);
        video->disk=disk;
        FreeFrame(video,frame);
    }
    Dprintf("VideoSave terminated\n");
}

void VideoDTSave(w,closure,call_data)

Widget      w;

```

- 375 -

```
caddr_t      closure, call_data;
```

```
{
```

```
    Video video;
```

```
    FILE *fp, *fopen();
```

```
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
```

```
    char  file_name[STRLEN], whole_frame[512][512];
```

```
    int   frame, i, x, y, offset[2];
```

```
    DTheader
```

```
header={ "DT-IMAGE",1,4,1,2,"", "",1,{0,0,4,0},1,1,0,1,{4,3},8,1,{0,2},{0,2},{0,2},{0,2}, "", "xwave generated image", ""};
```

```
    Dprintf("VideoDTSave %s\n",name->string);
```

```
    video=FindVideo(name->string,global->videos);
```

```
    sprintf(file_name, "%s%s/%s/%s%s", global->home, IMAGE_DIR, video->path, video->files, ".img");
```

```
    offset[0]=(512-video->size[0])/2;
```

```
    offset[1]=(512-video->size[1])/2;
```

```
    offset[0]=offset[0]<0?0:offset[0];
```

```
    offset[1]=offset[1]<0?0:offset[1];
```

```
    fp=fopen(file_name, "w");
```

```
    fwrite(&header,1,sizeof(DTheader),fp);
```

```
    GetFrame(video,0);
```

```
    for(y=0;y<512;y++) for(x=0;x<512;x++) {
```

```
        int   X, Y, oct;
```

```
        if (y<offset[1] || x<offset[0] || y-offset[1]>=video->size[1] ||
```

```
        x-offset[0]>=video->size[0]) whole_frame[y][x]=0;
```

```
        else {
```

```
            if (video->trans.type==TRANS_Wave) {
```

- 376 -

```
CvtIndex(x-offset[0],y-offset[1],video->size[0],video->size[1],video->trans.wavelet.space[0],&X,&Y,&oct);
```

```
whole_frame[y][x]=128+Round(video->data[0][0][Y*video->size[0]+X]*(oct==video->trans.wavelet.space[0]?1:4),video->precision);
```

```
    } else {
```

```
        X=x-offset[0]; Y=y-offset[1];
```

```
whole_frame[y][x]=128+Round(video->data[0][0][Y*video->size[0]+X],video->precision);
```

```
    }
```

```
  }
```

```
}
```

```
FreeFrame(video,0);
```

```
fwrite(whole_frame,1,512*512,fp);
```

```
fclose(fp);
```

```
}
```

```
void VideoXimSave(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
    Video video;
```

```
    FILE *fp, *fopen();
```

```
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
```

```
    char file_name[STRLEN], *whole_frame;
```

```
    int frame, channel, i, x, y;
```

```
    ImageHeader header;
```

```
Dprintf("VideoXimSave %s\n",name->string);
```



- 377 -

```

video=FindVideo(name->string,global->videos);
whole_frame=(char *)MALLOC(video->size[0]*video->size[1]);
if (video->files[0]!='\0') strcpy(video->files,name->string);

sprintf(file_name,"%s%s/%s/%s%s\0",global->home,IMAGE_DIR,video->path,video-
>files, ".xim");
fp=fopen(file_name,"w");
sprintf(header.file_version,"%8d",IMAGE_VERSION);
sprintf(header.header_size,"%8d",1024);
sprintf(header.image_width,"%8d",video->size[0]);
sprintf(header.image_height,"%8d",video->size[1]);
sprintf(header.num_colors,"%8d",256);
sprintf(header.num_channels,"%8d",video->type==MONO?1:3);
sprintf(header.num_pictures,"%8d",video->size[2]);
sprintf(header.alpha_channel,"%4d",0);
sprintf(header.runlength,"%4d",0);
sprintf(header.author,"%48s","xwave");
sprintf(header.date,"%32s","Now");
sprintf(header.program,"%16s","xwave");
for(i=0;i<256;i++) {
    header.c_map[i][0]=(unsigned char)i;
    header.c_map[i][1]=(unsigned char)i;
    header.c_map[i][2]=(unsigned char)i;
}
fwrite(&header,1,sizeof(ImageHeader),fp);
for (frame=video->start;frame<video->start+video->size[2];frame++) {
    GetFrame(video,frame-video->start);
    for(channel=0;channel<(video->type==MONO?1:3);channel++) {
        for(x=0;x<video->size[0];x++)
            for(y=0;y<video->size[1];y++)

whole_frame[x+video->size[0]*y]=itc(video->data[channel][frame-video->start][Addre

```

- 378 -

```

ss(video,channel,x,y)] > > video->precision);
        fwrite(whole_frame,sizeof(char),video->size[0]*video->size[1],fp);
    }
    FreeFrame(video,frame-video->start);
}
fclose(fp);
XtFree(whole_frame);
}

```

```

void VideoMacSave(w,closure,call_data)

```

```

Widget      w;

```

```

caddr_t      closure, call_data;

```

```

{
    Video video;
    FILE *fp, *fopen();
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
    char file_name[STRLEN], *whole_frame;
    int frame, channel, i, x, y;

```

```

    Dprintf("VideoMacSave %s\n",name->string);

```

```

    video=FindVideo(name->string,global->videos);

```

```

    if (video->files[0] == '\0') strcpy(video->files,name->string);

```

```

    sprintf(file_name,"%s%s/ %s/ %s%s\0",global->home,IMAGE_DIR,video->path,video-
    >files, ".mac");

```

```

    fp=fopen(file_name,"w");

```

```

    whole_frame=(char *)MALLOC(video->size[1]*video->size[0]*3);

```

```

    for(frame=0;frame<video->size[2];frame++) {

```

```

        int size=video->size[0]*video->size[1];

```

- 379 -

```

    GetFrame(video, frame);
    for(channel=0; channel < (video->type == MONO?1:3); channel++)
        for(x=0; x < video->size[0]; x++)
            for(y=0; y < video->size[1]; y++)

whole_frame[(x+video->size[0]*y)*3+channel]=itc(video->data[channel][frame][Address(video, channel, x, y)] > > video->precision);
    fwrite(whole_frame, 1, 3*size, fp);
    FreeFrame(video, frame);
}
fclose(fp);
XtFree(whole_frame);
}

```

```
void VideoHexSave(w, closure, call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
    Video video;
```

```
    FILE *fp, *fopen();
```

```
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
```

```
    char file_name[STRLEN];
```

```
    int frame, channel, i;
```

```
    Dprintf("VideoHexSave %s\n", name->string);
```

```
    video=FindVideo(name->string, global->videos);
```

```
    if (video->files[0] == '\0') strcpy(video->files, name->string);
```

```
    sprintf(file_name, "%s%s/%s/%s%s\0", global->home, IMAGE_DIR, video->path, video->files, ".h");
```

- 380 -

```

fp=fopen(file_name,"w");
for(frame=0;frame<(video->size[2]>2?2:video->size[2]);frame++) {
    int    size=video->size[1]*video->size[0];

    GetFrame(video,frame);
    fprintf(fp,"char
%s%d[%d]={\n",name->string[strlen(name->string)-1]=='d'? "src": "dst",frame,size);
    for(i=0;i<size;i++)

fprintf(fp,"0x%02x,%c",(video->data[0][frame][i]>>video->precision)+128,i%20==
19?'\\n':' ');

    fprintf(fp,"\\n};\\n");
    FreeFrame(video,frame);
}
fclose(fp);
}

```

```
#define AB_WIDTH 1440
```

```
#define AB_HEIGHT 486
```

```
void  VideoAbekusSave(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
    AbekusCtrl  ctrl=(AbekusCtrl)closure;
```

```
    FILE  *fp, *fopen();
```

```
    char  file_name[STRLEN], *data=(char
```

```
*)MALLOC(AB_WIDTH*AB_HEIGHT), zero=itc(0);
```

```
    int    frame, channel, i, x, y, length=0;
```

```
    Video  vids[4];
```

- 381 -

```

Dprintf("VideoAbekusSave\n");
for(i=0;i<4;i++)
    if (ctrl->names[i]!=NULL) {
        vids[i]=FindVideo(ctrl->names[i],global->videos);
        length=length>vids[i]->size[2]?length:vids[i]->size[2];
    } else vids[i]=NULL;
for(frame=0;frame<length;frame++) {
    sprintf(file_name,"%d.yuv\0",frame+1);
    fp=fopen(file_name,"w");
    for(i=0;i<4;i++) GetFrame(vids[i],frame);
    for(y=0;y<AB_HEIGHT;y++)
        for(x=0;x<AB_WIDTH;x++) {
            int
i=(x<AB_WIDTH/2?0:1)+(y<AB_HEIGHT/2?0:2),
            Y=y<AB_HEIGHT/2?y:y-AB_HEIGHT/2,
            X=(x<AB_WIDTH/2?x:x-AB_WIDTH/2)/2,
            channel=((x&1)==1)?0:((X&1)==0)?1:2;

            if (vids[i]->type==MONO && channel!=0 ||
X>=vids[i]->size[0] || Y>=vids[i]->size[1]) data[x+y*AB_WIDTH]=zero;
            else
data[x+y*AB_WIDTH]=itc(vids[i]->data[channel][frame][Address(vids[i],channel,X,Y)]
>>vids[i]->precision);
        }
    for(i=0;i<4;i++) {
        FreeFrame(vids[i],frame);
        EraseFrame(vids[i],frame);
    }
    fwrite(data,1,AB_WIDTH*AB_HEIGHT,fp);
    fclose(fp);
}
}

```

- 382 -

```
void VideoDrop(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
Video *videos=&global-> videos, video;
```

```
XawListReturnStruct *name=(XawListReturnStruct *)call_data;
```

```
int  channel, frame;
```

```
Dprintf("VideoDrop %s\n",name-> string);
```

```
video=FindVideo(name-> string,global-> videos);
```

```
while (*videos!=video && *videos!=NULL) videos=&((*videos)-> next);
```

```
if (*videos!=NULL) {
```

```
    *videos=(*videos)-> next;
```

```
    for(channel=0;channel<(video-> type==MONO?1:3);channel++)
```

```
        if (video-> data[channel]!=NULL) {
```

```
            for(frame=0;frame< video-> size[2];frame++)
```

```
                if (video-> data[channel][frame]!=NULL)
```

```
                    XtFree(video-> data[channel][frame]);
```

```
                    XtFree(video-> data[channel]);
```

```
            }
```

```
        XtFree(video);
```

```
    }
```

```
}
```

```
/* Obsolete
```

```
void VideoDiff(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

- 383 -

```

XawListReturnStruct *name=(XawListReturnStruct *)call_data;
Video src=FindVideo(name->string,global->videos), dst=CopyHeader(src);
int frame, channel, i;

printf("VideoDiff %s\n",name->string);
sprintf(dst->name,"%s.dif\0",src->name);
for(frame=0;frame<src->size[2];frame++) {
    GetFrame(src,frame);
    NewFrame(dst,frame);
    for(channel=0;channel<(video->type==MONO?1:3);channel++)
        for(i=0;i<src->size[1]*src->size[0];i++)

dst->data[channel][frame][i]=src->data[channel][frame][i]-(frame==0?0:src->data[channel][frame-1][i]);

    SaveFrame(dst,frame);
    FreeFrame(dst,frame);
    if (frame>0) FreeFrame(src,frame-1);
}
FreeFrame(dst,src->size[2]-1);
dst->next=global->videos;
global->videos=dst;
}
*/
void VideoClean(w,closure,call_data)

Widget w;
caddr_t closure, call_data;

{
    Video *videos=&global->videos, video;
    int channel, frame;

```

- 384 -

```

Dprintf("VideoClean\n");
while(*videos!=NULL) {
    video=*videos;
    if (False == VideoHasFrame(video,global->frames)) {
        Dprintf("Erasing video: %s\n",video->name);

for(channel=0;channel<(video->type==MONO?1:3);channel++)
        if (video->data[channel]!=NULL) {
            for(frame=0;frame<video->size[2];frame++)
                if (video->data[channel][frame]!=NULL)
XtFree(video->data[channel][frame]);
            XtFree(video->data[channel]);
        }
        *videos=video->next;
        XtFree(video);
    } else videos=&(*videos)->next;
}
}

typedef struct {
    Frame frame;
    XtIntervalId id;
    unsigned long interval;
    long msec, shown, average;
    Pixmap *movie;
    int fno, old_fno;
} MovieArgRec, *MovieArg;

void Projector(client_data,id)

XtPointer client_data;
XtIntervalId *id;

```



- 385 -

```

{
    MovieArg    movieArg=(MovieArg)client_data;
    Display      *dpy=XtDisplay(global->toplevel);
    struct timeval    tp;
    struct timezone    tzp;
    long    new_msec;
    int     scrn=XDefaultScreen(dpy);

movieArg->id=XtAppAddTimeOut(global->app_con,movieArg->interval,Projector,movieArg);

    gettimeofday(&tp,&tzp);
    new_msec=tp.tv_sec*1000+tp.tv_usec/1000;
    if (movieArg->msec!=0) {

movieArg->average=(movieArg->average*movieArg->shown+new_msec-movieArg->msec)/(movieArg->shown+1);
        movieArg->shown++;
    }
    movieArg->msec=new_msec;

XCopyArea(dpy,movieArg->movie[movieArg->fno],XtWindow(movieArg->frame->image_widget),DefaultGC(dpy,scrn),0,0,movieArg->frame->video->size[0],movieArg->frame->video->size[1],0,0);

movieArg->fno=movieArg->fno==movieArg->frame->video->size[2]-1?0:movieArg->fno+1;
}

void    StopMovie(w,closure,call_data)

Widget    w;

```

- 386 -

```

caddr_t      closure, call_data;

{
    MovieArg   movieArg=(MovieArg)closure;
    Display     *dpy=XtDisplay(global->toplevel);
    int        i;
    Arg         args[1];

    XtRemoveTimeout(movieArg->id);
    Dprintf("Movie showed %d frames at an average of %f
fps\n",movieArg->shown,1000.0/(float)movieArg->average);
    for(i=0;i<movieArg->frame->video->size[2];i++)
XFreePixmap(dpy,movieArg->movie[i]);
    XtFree(movieArg->movie);
    XtSetArg(args[0],XtNbitmap,UpdateImage(movieArg->frame));
    XtSetValues(movieArg->frame->image_widget,args,ONE);
    XSynchronize(dpy,False);
}

#define      MOVIE_ICONS      1

void  Movie(w,closure,call_data)

Widget      w;
caddr_t      closure, call_data;

{
    Video video=((Frame)closure)->video;
    MovieArg   movieArg=(MovieArg)MALLOC(sizeof(MovieArgRec));
    Widget      shell=ShellWidget("movie",XtParent(w),SW_over,NULL,NULL),
                form=FormatWidget("movie_form",shell),
widgets[MOVIE_ICONS];

```

- 387 -

```

Display      *dpy=XtDisplay(global->toplevel);
FormItem     items[]={
    {"movie_stop","stop",0,0,FW_icon,NULL},
};
XtCallbackRec callbacks[]={
    {StopMovie,(caddr_t)movieArg},
    {Free,(caddr_t)movieArg},
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
};
int          i;
XGCValues    values;
GC           gc;

Dprintf("Movie\n");

FillForm(form,MOVIE_ICONS,items,widgets,callbacks);
XtPopup(shell,XtGrabExclusive);

values.foreground=255;
values.background=0;
gc=XtGetGC(XtParent(w),GCForeground | GCBackground,&values);
movieArg->frame=(Frame)closure;
movieArg->movie=(Pixmap *)MALLOC(video->size[2]*sizeof(Pixmap));
movieArg->old_fno=movieArg->frame->frame;
for(i=0;i<video->size[2];i++) {
    char    fno[STRLEN];

    sprintf(fno,"%03d\0",i+video->start);
    movieArg->frame->frame=i;
    GetFrame(video,i);
    movieArg->movie[i]=UpdateImage(movieArg->frame);
}

```

- 388 -

```

XDrawImageString(dpy, movieArg->movie[i], gc, video->size[0]-50, 10, fno, 3);

XCopyArea(dpy, movieArg->movie[i], XtWindow(movieArg->frame->image_widget), D
efaultGC(dpy, 0), 0, 0, video->size[0], video->size[1], 0, 0);
        movieArg->frame->frame=movieArg->old_fno;
        FreeFrame(video, i);
    }
    XtDestroyGC(gc);
    movieArg->fno=0;
    movieArg->msec=0;
    movieArg->shown=0;
    movieArg->average=0;
    movieArg->interval=1000/video->rate;

movieArg->id=XtAppAddTimeOut(global->app_con, movieArg->interval, Projector, mo
vieArg);
        XSynchronize(dpy, True);
    }

void Compare(w, closure, call_data)

Widget      w;
caddr_t     closure, call_data;

{
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
    Video src=(Video)closure, dst=FindVideo(name->string, global->videos);
    int channels=src->type==MONO || dst->type==MONO?1:3, channel,
values=0, x, y,
        frames=src->size[2]>dst->size[2]?dst->size[2]:src->size[2],
frame;

```

- 389 -

```

double      mse;
Message     msg=NewMessage(NULL,400);
XtCallbackRec  callbacks[]={
    {CloseMessage,(caddr_t)msg}, {NULL,NULL},
};

msg->rows=frames>5?10:2*frames; msg->cols=40;
if (global->batch==NULL)
MessageWindow(FindWidget("frm_compare",w),msg,"Compare",True,callbacks);
    for(frame=0;frame<frames;frame++) {
        Boolean      srcp=src->precision>dst->precision;
        int          err_sqr=0,
precision=srcp?src->precision-dst->precision:dst->precision-src->precision;

        Mprintf(msg,"Compare: %s%03d and
%s%03d\n",src->name,src->start+frame,dst->name,dst->start+frame);
        GetFrame(src,frame);
        GetFrame(dst,frame);
        for(channel=0;channel<channels;channel++) {

values += Size(src->size[1]>dst->size[1]?dst:src,channel,1)*Size(src->size[0]>dst->s
ize[0]?dst:src,channel,0);

for(y=0;y<Size(src->size[1]>dst->size[1]?dst:src,channel,1);y++)

for(x=0;x<Size(src->size[0]>dst->size[0]?dst:src,channel,0);x++) {
            int
err=(src->data[channel][frame][x+Size(src,channel,0)*y]<<(srcp?0:precision))-(dst->
data[channel][frame][x+Size(dst,channel,0)*y]<<(srcp?precision:0));

            err_sqr += err*err;
        }
    }

```

- 390 -

```

    }
    FreeFrame(src,frame);
    FreeFrame(dst,frame);
    mse=(double)err_sqr/(double)(values);
    Mprintf(msg,"Error %d MSE %f PSNR
%f\n",err_sqr,mse,10*log10(pow((pow(2.0,(double)(8+(srcp?src->precision:dst->precis
ion)))-1),2.0)/mse));
    Mflush(msg);
}
}

```

```

void BatchCompare(w,closure,call_data)

```

```

Widget      w;
caddr_t     closure, call_data;

{
    String name=(String)closure;

    closure=(caddr_t)FindVideo(name,global->videos);
    Compare(w,closure,call_data);
}

```

- 391 -

source/xwave.c

```
#include    "../include/xwave.h"
#include    <X11/Xresource.h>
#include    <X11/Intrinsic.h>
#include    <X11/Quarks.h>
```

```
extern Palette      ReOrderPalettes();
extern void  NameButton();
extern void  ImageNotify();
extern void  Parse();
```

```
#define    IconPath      "bitmaps"
#define    IconFile      "xwave.icons"
#define    CompressPath      "."
#define    CompressExt  ".compress"
#define    PalettePath   "."
#define    PaletteExt    ".pal"
```

```
Global      global;
```

```
String ChannelName[3][4]={
    {"GreyScale",NULL,NULL,NULL},
    {"Red  ", "Green", "Blue ", "Color"},
    {"Y-Lumunance", "U-Chrome  ", "V-Chrome  ", "Color  "},
};
```

```
#define    XtNdebug  "debug"
#define    XtNbatch  "batch"
```

- 392 -

```

static XtResource  resources[] = {
    {XtNdebug, XtCBoolean, XtRBoolean, sizeof(Boolean),
     XtOffset(Global,debug), XtRString, "false"},
    {XtNbatch, XtCFile, XtRString, sizeof(String),
     XtOffset(Global,batch), XtRString, NULL},
};

static XrmOptionDescRec  options[]={
    {"-debug", "*debug", XrmoptionNoArg, "true"},
    {"-batch", "*batch", XrmoptionSepArg, NULL},
};

static Boolean      CvtStringToPixel2();

#ifdef __STDC__
externref  XtConvertArgRec  const colorConvertArgs[2];
#else
externref XtConvertArgRec colorConvertArgs[2];
#endif

static String fallback_resources[]={
    "**copy_video*Toggle*translations: #override \\n <Btn1Down>, <Btn1Up>:
set() notify()",
    "**copy_video*copy*state: true",
    NULL,
};

XtActionsRec      actionTable[]={
    {"NameButton", NameButton},
};

main(argc,argv,envp)

```



- 393 -

```

int    argc;
char   *argv[], *envp[];

{
    void    InitPixmaps(), InitActions(), InitMain(), InitEnv(), InitDither(), Dispatch();
    GlobalRec    globalrec;

    global=&globalrec;
    global->videos=NULL;
    global->frames=NULL;
    global->points=NULL;
    InitEnv(envp);

    global->toplevel=XtAppInitialize(&(global->app_con),"xwave",options,XtNumber(options),&argc,argv,fallback_resources,NULL,ZERO);

    XtGetApplicationResources(global->toplevel,global,resources,XtNumber(resources),NULL,ZERO);
    if (global->batch!=NULL) {
        Parse(BATCH_DIR,global->batch,BATCH_EXT);
        if (global->batch_list!=NULL) Dispatch(global->batch_list);
    }
    if (global->batch==NULL) {
        XtAppAddActions(global->app_con,actionTable,XtNumber(actionTable));

    XtSetTypeConverter(XtRString,XtRPixel,CvtStringToPixel2,colorConvertArgs,XtNumber(colorConvertArgs),XtCacheByDisplay,NULL);
        if (global->debug) Dprintf("Xwave Debugging Output\n");
        InitVisual();
        InitDither();
        InitPixmaps(IconPath,IconFile);
        Parse(PalettePath,"xwave",PaletteExt);

```

- 394 -

```

        global->palettes=ReOrderPalettes(global->palettes,global->palettes);
        InitActions(global->app_con);
        InitMain();
        XtRealizeWidget(global->toplevel);
        XtAppMainLoop(global->app_con);
    }
}

```

```
void  InitEnv(envp)
```

```
char  *envp[];
```

```

{
    String home=NULL, xwave=NULL;

    Dprintf("Initializing enviroment\n");
    while(*envp!=NULL) {
        if(!strcmp(*envp,"HOME=",5)) home=(*envp)+5;
        if(!strcmp(*envp,"XWAVE=",6)) xwave=(*envp)+6;
        envp++;
    }
    if (xwave!=NULL) sprintf(global->home,"%s/",xwave);
    else sprintf(global->home,"%s/xwave/",home);
}

```

```
#define      HEIGHT      14
```

```
void  InitPixmap(path,file)
```

```
char  *file, *path;
```

```
{
```

- 395 -

```

FILE *fp, *fopen();
Icon icons;
char pad[100];
Display *dpy=XtDisplay(global->toplevel);
int i, j, sink, scrn=XDefaultScreen(dpy), depth=DisplayPlanes(dpy,scrn),
    bpl=(global->levels*depth+7)/8;
char data[HEIGHT*bpl];
XImage
*image=XCreateImage(dpy,global->visinfo->visual,depth,ZPixmap,0,data,global->levels,HEIGHT,8,bpl);

sprintf(pad,"%s%s/%s\0",global->home,path,file);
if (NULL == (fp=fopen(pad,"r"))) {
    Eprintf("Can't open file %s\n",pad);
    exit();
}
fscanf(fp,"%d\n",&global->no_icons);
global->icons=(Icon)MALLOC((1+global->no_icons)*sizeof(IconRec));
for(i=0;i<global->no_icons;i++) {
    global->icons[i].name=(String)MALLOC(100);
    fscanf(fp,"%s\n",global->icons[i].name);
    sprintf(pad,"%s%s/%s\0",global->home,path,global->icons[i].name);
    XReadBitmapFile(
        XtDisplay(global->toplevel),
        XDefaultRootWindow(dpy),
        pad,
        &global->icons[i].width,
        &global->icons[i].height,
        &global->icons[i].pixmap,
        &sink,
        &sink
    );
}

```

- 396 -

```

    }
    global->icons[global->no_icons].name=(String)MALLOC(100);
    strcpy(global->icons[global->no_icons].name,"colors");
    global->icons[global->no_icons].width=global->levels;
    global->icons[global->no_icons].height=HEIGHT;
    for(i=0;i<global->levels;i++)
        for(j=0;j<HEIGHT;j++) XPutPixel(image,i,j,i);

    global->icons[global->no_icons].pixmap=XCreatePixmap(dpy,XDefaultRootWindow(dp
y),global->levels,HEIGHT,depth);

    XPutImage(dpy,global->icons[global->no_icons].pixmap,DefaultGC(dpy,scrn),image,0,0
,0,0,global->levels,HEIGHT);
    global->no_icons++;
    XtFree(image);
    fclose(fp);
}

#define done(type, value) \
{ \
    if (toVal->addr != NULL) { \
        if (toVal->size < sizeof(type)) { \
            toVal->size = sizeof(type); \
            return False; \
        } \
        *(type*)(toVal->addr) = (value); \
    } \
    else { \
        static type static_val; \
        static_val = (value); \
        toVal->addr = (XtPointer)&static_val; \
    } \
}

```

- 397 -

```

        toVal->size = sizeof(type);
        return True;
    }

#define      dist(colora,colorb) \

abs(colora.red-colorb.red)+abs(colora.green-colorb.green)+abs(colora.blue-colorb.blue)

static Boolean CvtStringToPixel2(dpy, args, num_args, fromVal, toVal, closure_ret)
    Display*  dpy;
    XrmValuePtr args;
    Cardinal  *num_args;
    XrmValuePtr  fromVal;
    XrmValuePtr  toVal;
    XtPointer  *closure_ret;
{
    String      str = (String)fromVal->addr;
    XColor      screenColor;
    XColor      exactColor;
    Screen      *screen;
    Colormap    colormap;
    Status      status;
    String      params[1];
    Cardinal     num_params=1;

    Dprintf("Convert string to pixel 2\n");
    if (*num_args != 2)
        XtAppErrorMsg(XtDisplayToApplicationContext(dpy), "wrongParameters",
            "cvtStringToPixel",
                "XtToolkitError",
                "String to pixel conversion needs screen and colormap arguments",
                (String *)NULL, (Cardinal *)NULL);

```

- 398 -

```

screen = *((Screen **) args[0].addr);
colormap = *((Colormap *) args[1].addr);

if (!strcmp(str,XtDefaultBackground)) {
    *closure_ret = False;
    done(Pixel,WhitePixelOfScreen(screen));
}
if (!strcmp(str,XtDefaultForeground)) {
    *closure_ret = False;
    done(Pixel,BlackPixelOfScreen(screen));
}
params[0]=str;
if (0==XParseColor(DisplayOfScreen(screen),colormap,str,&screenColor)) {
    XtAppWarningMsg(XtDisplayToApplicationContext(dpy), "noColormap",
"cvStringToPixel",
    "XtToolkitError", "Cannot parse color: \"%s\"",
params,&num_params);
    return False;
} else {
if (0==XAllocColor(DisplayOfScreen(screen),colormap,&screenColor)) {
    int i, delta, closest=0;
    XColor colors[global->levels];

    for(i=0;i<global->levels;i++) colors[i].pixel=i;

XQueryColors(DisplayOfScreen(screen),colormap,colors,global->levels);
    delta=dist(screenColor,colors[0]);
    for(i=1;i<global->levels;i++) {
        int delta_new=dist(screenColor,colors[i]);

        if (delta_new<delta) {
            delta=delta_new;

```

- 399 -

```

        closest=i;
    }
}
Dprintf("Closest color to %s is pixel %d red %d green %d blue
%d\n",str,colors[closest].pixel,colors[closest].red,colors[closest].green,colors[closest].blue
);
    *closure_ret = (char*)True;
    done(Pixel, closest);
} else {
    *closure_ret = (char*)True;
    done(Pixel, screenColor.pixel);
}
}
}

```

```
void Dispatch(list)
```

```
Batch list;
```

```

{
    if (list->next!=NULL) Dispatch(list->next);
    (list->proc)(NULL,list->closure,list->call_data);
    if (list->closure!=NULL) XtFree(list->closure);
    if (list->call_data!=NULL) XtFree(list->call_data);
    XtFree(list);
}

```

```
void BatchCtrl(w,closure,call_data)
```

```

Widget      w;
caddr_t     closure, call_data;

```

- 400 -

```

{
    Dprintf("BatchCtrl\n");
    global->batch=(String)closure;
}

void UnixShell(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    if (-1 == Fork((char **)closure)) Eprintf("Unable to fork\n");
}

void InitDither()

{
    int      i, j, k, l,
            dm4[4][4]={
                0, 8, 2, 10,
                12, 4, 14, 6,
                3, 11, 1, 9,
                15, 7, 13, 5
            };

    for(i=0;i<4;i++)
        for(j=0;j<4;j++)
            for(k=0;k<4;k++)
                for(l=0;l<4;l++)

global->dither[4*k+i][4*l+j]=(dm4[i][j]<<4)+dm4[k][l];
}

```



- 401 -

## source/Copy.h

```
typedef struct {  
    Video video;  
    char  name[STRLEN], src_name[STRLEN];  
    int   UVsample[2];  
    int   mode;  
    Widget radioGroup;  
} CopyCtrlRec, *CopyCtrl;
```

- 402 -

source/Gram.y

```
%{

/*
 *   Grammar for files: .elo
 */

#include      "../include/xwave.h"
#include      "Klics.h"
#include      "Transform.h"
#include      "Copy.h"
#include      "Video.h"
extern void   VideoLoad();
extern void   VideoSave();
extern void   VideoDrop();
extern void   ImportKlics();
extern void   VideoAbekusSave();
extern void   UnixShell();
extern void   BatchCompCtrl();
extern void   BatchTransCtrl();
extern void   BatchCopyCtrl();
extern void   BatchCompare();
extern void   BatchCtrl();
extern CompCtrl   InitCompCtrl();
extern CopyCtrl   InitCopyCtrl();
extern TransCtrl  InitTransCtrl();

static char  *ptr;
void  NewBatch();

}%}
```

- 403 -

%union

{

double fnum;

int num;

char \*ptr;

Boolean bool;

};

%token SIZE TRANSFORM TRANSFORM\_NONE TRANSFORM\_WAVE PATH

%token FILE\_PAL PALETTE RANGE LINE

%token FILE\_VID TYPE FORMAT\_MONO FORMAT\_RGB FORMAT\_YUV

RATE DISK GAMMA PATH FILES START END LEN DIM HEADER OFFSETS

NEGATIVE PRECISION

%token FILE\_BAT LOAD SAVE SAVE\_ABEKUS COMPARE DROP

COMPRESS VIDEO\_NAME STATS\_NAME BIN\_NAME

%token STILL\_MODE VIDEO\_MODE AUTO\_Q QUANT\_CONST

THRESH\_CONST BASE\_FACTOR DIAG\_FACTOR CHROME\_FACTOR

%token DECISION DEC\_MAX DEC\_SIGABS DEC\_SIGSQR FEEDBACK

FILTER FLT\_NONE FLT\_EXP CMP\_CONST SPACE LEFT\_BRACE RIGHT\_BRACE

DIRECTION

%token FPS BITRATE BUFFER XWAVE SHELL IMPORT\_KLICS

%token COPY DIRECT\_COPY DIFF LPF\_WIPE LPF\_ONLY RGB\_YUV

%token &lt; num &gt; NUMBER

%token &lt; ptr &gt; STRING

%token &lt; fnum &gt; FNUMBER

%token &lt; bool &gt; BOOLEAN

%type &lt; num &gt; number video\_type decision filter

%type &lt; ptr &gt; string

%type &lt; fnum &gt; fnumber

%type &lt; bool &gt; boolean

- 404 -

```
%start wait
```

```
%%
```

```
wait :
```

```
    | pal_id pal_desc
    | video_id video_desc
    | bat_id bat_desc bat_end;
```

```
pal_id : FILE_PAL {
```

```
    Dprintf("Gram: palette file %s\n",global->parse_file);
```

```
};
```

```
video_id : FILE_VID {
```

```
    Dprintf("Gram: video file %s\n",global->parse_file);
```

```
    global->videos->start=1;
```

```
    global->videos->size[2]=1;
```

```
};
```

```
bat_id : FILE_BAT {
```

```
    Dprintf("Gram: batch file %s\n",global->parse_file);
```

```
};
```

```
pal_desc :
```

```
    | pal_desc palette LEFT_BRACE mappings RIGHT_BRACE;
```

```
palette : PALETTE string {
```

```
    Palette pal=(Palette)MALLOC(sizeof(PaletteRec));
```

```
    Dprintf("Gram: palette %s\n",$2);
```

```
    strcpy(pal->name,$2);
```

```
    pal->mappings=NULL;
```

- 405 -

```

        pal->next=global->palettes;
        global->palettes=pal;
        global->no_pals++;
    };

mappings      :
    | mappings mapping;

mapping       : RANGE number number LINE number number {
    Map  map=(Map)MALLOC(sizeof(MapRec));

    Dprintf("Gram: Range %d to %d m=%d c=%d\n", $2, $3, $5, $6);
    map->start=$2;
    map->finish=$3;
    map->m=$5;
    map->c=$6;
    map->next=global->palettes->mappings;
    global->palettes->mappings=map;
};

video_desc    : video_defs {
    if (global->videos->size[0]==0 &&
global->videos->size[1]==0) {
        global->videos->size[0]=global->videos->cols;
        global->videos->size[1]=global->videos->rows;
    }
};

video_defs    :
    | video_defs video_def;

video_def     : PATH string {

```

- 406 -

```

        Dprintf("Video path %s\n", $2);
        strcpy(global->videos->path, $2);
    }
    | FILES string {
        Dprintf("Frames stored in %s\n", $2);
        strcpy(global->videos->files, $2);
    }
    | TYPE video_type {
        String types[] = {"Mono", "RGB", "YUV"};

        Dprintf("Video type: %s\n", types[$2]);
        global->videos->type = (VideoFormat)$2;
    }
    | RATE number {
        Dprintf("Video rate %d fps\n", $2);
        global->videos->rate = $2;
    }
    | DISK {
        Dprintf("Frames on disk\n");
        global->videos->disk = True;
    }
    | GAMMA {
        Dprintf("Gamma corrected\n");
        global->videos->gamma = True;
    }
    | NEGATIVE {
        Dprintf("Negative video\n");
        global->videos->negative = True;
    }
    | TRANSFORM video_transform
    | START number {
        Dprintf("Video start %03d\n", $2);

```

- 407 -

```

        global->videos->start=$2;
    }
    | END number {
        Dprintf("Video end %03d\n",$2);
        global->videos->size[2]=$2-global->videos->start+1;
    }
    | LEN number {
        Dprintf("Video frames %d\n",$2);
        global->videos->size[2]=$2;
    }
    | DIM number number {
        Dprintf("Video dimensions %d %d\n",$2,$3);
        global->videos->cols=$2;
        global->videos->rows=$3;
    }
    | HEADER number {
        Dprintf("Video header size %d\n",$2);
        global->videos->offset=$2;
    }
    | OFFSETS number number {
        Dprintf("Video offsets %d %d\n",$2,$3);
        global->videos->x_offset=$2;
        global->videos->y_offset=$3;
    }
    | SIZE number number {
        Dprintf("Video size %d %d\n",$2,$3);
        global->videos->size[0]=$2;
        global->videos->size[1]=$3;
    }
    | PRECISION number {
        Dprintf("Video precision %d bits\n",8+$2);
        global->videos->precision=$2;
    }

```

- 408 -

```

};

video_type    : FORMAT_MONO { $$=(int)MONO; }
               | FORMAT_RGB { $$=(int)RGB; }
               | FORMAT_YUV number number { $$=(int)YUV;
global-> videos-> UVsample[0]=$2; global-> videos-> UVsample[1]=$3; };

video_transform : TRANSFORM_NONE {
               global-> videos-> trans.type=TRANS_None;
               }
               | TRANSFORM_WAVE number number boolean {
               Dprintf("Video wavelet transformed %d %d
%s\n",$2,$3,$4?"True":"False");
               global-> videos-> trans.type=TRANS_Wave;
               global-> videos-> trans.wavelet.space[0]=$2;
               global-> videos-> trans.wavelet.space[1]=$3;
               global-> videos-> trans.wavelet.dirn=$4;
               };

bat_end       :
               | XWAVE {
               Dprintf("Gram: XWAVE\n");
               NewBatch(BatchCtrl,(caddr_t)NULL,NULL);
               };

bat_desc      : bat_cmds {
               Dprintf("Gram: End of batch file\n");
               };

bat_cmds      :
               | bat_cmds bat_cmd;

```



- 409 -

```

bat_cmd      : simple_cmd
               | complex_cmd
               ;

simple_cmd    : LOAD string {
               XawListReturnStruct *list_return=(XawListReturnStruct
               *)MALLOC(sizeof(XawListReturnStruct));

               Dprintf("Gram: LOAD %s\n",$2);
               list_return->string=$2;
               NewBatch(VideoLoad,NULL,(caddr_t)list_return);
               }
               | SAVE string {
               XawListReturnStruct *list_return=(XawListReturnStruct
               *)MALLOC(sizeof(XawListReturnStruct));

               Dprintf("Gram: SAVE %s\n",$2);
               list_return->string=$2;
               NewBatch(VideoSave,NULL,(caddr_t)list_return);
               }
               | SAVE_ABEKUS string string string string {
               AbekusCtrl
               ctrl=(AbekusCtrl)MALLOC(sizeof(AbekusCtrlRec));

               Dprintf("Gram: SAVE_ABEKUS %s %s %s
               %s\n",$2,$3,$4,$5);

               strcpy(ctrl->names[0],$2);
               strcpy(ctrl->names[1],$3);
               strcpy(ctrl->names[2],$4);
               strcpy(ctrl->names[3],$5);
               NewBatch(VideoAbekusSave,(caddr_t)ctrl,NULL);
               }

```

- 410 -

```

| COMPARE string string {
    XawListReturnStruct *list_return=(XawListReturnStruct
*)MALLOC(sizeof(XawListReturnStruct));

    Dprintf("Gram: COMPARE %s with %s\n", $2, $3);
    list_return->string=$2;
    NewBatch(BatchCompare, (caddr_t)$3, (caddr_t)list_return);
}
| DROP string {
    XawListReturnStruct *list_return=(XawListReturnStruct
*)MALLOC(sizeof(XawListReturnStruct));

    Dprintf("Gram: DROP %s\n", $2);
    list_return->string=$2;
    NewBatch(VideoDrop, NULL, (caddr_t)list_return);
}
| IMPORT_KLICS string {
    XawListReturnStruct *list_return=(XawListReturnStruct
*)MALLOC(sizeof(XawListReturnStruct));

    Dprintf("Gram: IMPORT_KLICS %s\n", $2);
    list_return->string=$2;
    NewBatch(ImportKlics, NULL, (caddr_t)list_return);
}
| SHELL string {
    char    **argv, *str=$2;
    int     c, argc=1, len=strlen(str);

    Dprintf("Shell %s\n", str);
    for(c=0; c<len; c++) if (str[c]==' ') {
        str[c]='\0';
        argc++;
    }
}

```

- 411 -

```

    }
    argv=(char **)MALLOC((argc+1)*sizeof(char *));
    argc=0;
    for(c=0;c<len;c+=1+strlen(str+c)) {
        argv[argc]=(char
*)MALLOC((strlen(str+c)+1)*sizeof(char));
        strcpy(argv[argc],str+c);
        argc++;
    }
    argv[argc]=NULL;
    NewBatch(UnixShell,(caddr_t)argv,NULL);
};

```

```

complex_cmd      : compress LEFT_BRACE comp_args RIGHT_BRACE
                  | transform LEFT_BRACE trans_args RIGHT_BRACE
                  | copy copy_arg;

```

```

compress        : COMPRESS string {
                  CompCtrl    ctrl=InitCompCtrl($2);

                  Dprintf("Gram: COMPRESS\n");
                  NewBatch(BatchCompCtrl,(caddr_t)ctrl,NULL);
                };

```

```

transform        : TRANSFORM string {
                  TransCtrl    ctrl=InitTransCtrl($2);

                  Dprintf("Gram: TRANSFORM\n");
                  NewBatch(BatchTransCtrl,(caddr_t)ctrl,NULL);
                };

```

```

copy             : COPY string string {

```

- 412 -

```

CopyCtrl    ctrl=InitCopyCtrl($2);
Dprintf("Gram: Copy\n");
strcpy(ctrl->name,$3);
NewBatch(BatchCopyCtrl,(caddr_t)ctrl,NULL);
};

comp_args   :
    | comp_args comp_arg;

trans_args  :
    | trans_args trans_arg;

copy_arg    : DIRECT_COPY number number {
    Dprintf("Gram: Direct Copy (sample %d %d)\n",$2,$3);
    ((CopyCtrl)global->batch_list->closure)->mode=1;

    ((CopyCtrl)global->batch_list->closure)->UVsample[0]=$2;

    ((CopyCtrl)global->batch_list->closure)->UVsample[1]=$3;
    }
    | DIFF {
    Dprintf("Gram: Differance Copy\n");
    ((CopyCtrl)global->batch_list->closure)->mode=2;
    }
    | LPF_WIPE {
    Dprintf("Gram: LPF zero\n");
    ((CopyCtrl)global->batch_list->closure)->mode=3;
    }
    | LPF_ONLY {
    Dprintf("Gram: LPF only\n");
    ((CopyCtrl)global->batch_list->closure)->mode=4;
    }

```

- 413 -

```

    | RGB_YUV {
        Dprintf("Gram: RGB/YUV\n");
        ((CopyCtrl)global->batch_list->closure)->mode=5;
    }
    | GAMMA {
        Dprintf("Gram: Gamma convert\n");
        ((CopyCtrl)global->batch_list->closure)->mode=6;
    };

comp_arg      : VIDEO_NAME string {
    Dprintf("Gram: Compress name %s\n",$2);

strcpy(((CompCtrl)global->batch_list->closure)->name,$2);
    }
    | STATS_NAME string {
        Dprintf("Gram: Stats name %s\n",$2);

strcpy(((CompCtrl)global->batch_list->closure)->stats_name,$2);

((CompCtrl)global->batch_list->closure)->stats_switch=True;
    }
    | BIN_NAME string {
        Dprintf("Gram: Bin name %s\n",$2);

strcpy(((CompCtrl)global->batch_list->closure)->bin_name,$2);

((CompCtrl)global->batch_list->closure)->bin_switch=True;
    }
    | STILL_MODE {
        Dprintf("Gram: Still\n");
        ((CompCtrl)global->batch_list->closure)->stillvid=True;
    }

```

- 414 -

```

| VIDEO_MODE {
    Dprintf("Gram: Video\n");
    ((CompCtrl)global->batch_list->closure)->stillvid=False;
}
| AUTO_Q boolean {
    Dprintf("Gram: Auto_q %s\n",$2?"True":"False");
    ((CompCtrl)global->batch_list->closure)->auto_q=$2;
}
| QUANT_CONST fnumber {
    Dprintf("Gram: Quant const %f\n",$2);

((CompCtrl)global->batch_list->closure)->quant_const=$2;
}
| THRESH_CONST fnumber {
    Dprintf("Gram: Thresh const %f\n",$2);

((CompCtrl)global->batch_list->closure)->thresh_const=$2;
}
| BASE_FACTOR number fnumber {
    Dprintf("Gram: Base factor oct %d=%f\n",$2,$3);

((CompCtrl)global->batch_list->closure)->base_factors[$2]=$3;
}
| DIAG_FACTOR fnumber {
    Dprintf("Gram: Diag factor %f\n",$2);
    ((CompCtrl)global->batch_list->closure)->diag_factor=$2;
}
| CHROME_FACTOR fnumber {
    Dprintf("Gram: Chrome factor %f\n",$2);

((CompCtrl)global->batch_list->closure)->chrome_factor=$2;
}

```

- 415 -

```

| DECISION decision {
    Dprintf("Gram: Decision changed\n");
    ((CompCtrl)global->batch_list->closure)->decide=$2;
}
| FEEDBACK number {
    ((CompCtrl)global->batch_list->closure)->feedback=$2;
    ((CompCtrl)global->batch_list->closure)->auto_q=True;
}
| FILTER filter {
    String filters[2]={"None","Exp"};
    Dprintf("Gram: Filter %s\n",filters[$2]);
    ((CompCtrl)global->batch_list->closure)->filter=$2;
}
| CMP_CONST fnumber {
    Dprintf("Gram: Comparison %f\n",$2);
    ((CompCtrl)global->batch_list->closure)->cmp_const=$2;
}
| FPS fnumber {
    Dprintf("Gram: Frame Rate %f\n",$2);
    ((CompCtrl)global->batch_list->closure)->fps=$2;
}
| BITRATE number {
    Dprintf("Gram: %dx64k/s\n",$2);
    ((CompCtrl)global->batch_list->closure)->bitrate=$2;
}
| BUFFER {
    Dprintf("Gram: Buffer on\n");

    ((CompCtrl)global->batch_list->closure)->buf_switch=True;
};

decision      : DEC_MAX{ $$ = 0; }

```

- 416 -

```

| DEC_SIGABS { $$ = 1; }
| DEC_SIGSQR { $$ = 2; };

filter      : FLT_NONE { $$ = 0; }
              | FLT_EXP { $$ = 1; };

trans_arg    : VIDEO_NAME string {
                Dprintf("Gram: Transform name %s\n", $2);

strcpy(((TransCtrl)global->batch_list->closure)->name, $2);
        }
        | DIRECTION boolean {
            Dprintf("Gram: Direction %s\n", $2?"True":"False");
            ((TransCtrl)global->batch_list->closure)->dirn=$2;
        }
        | SPACE number number {
            Dprintf("Gram: Space %d %d\n", $2, $3);
            ((TransCtrl)global->batch_list->closure)->space[0]=$2;
            ((TransCtrl)global->batch_list->closure)->space[1]=$3;
        }
        | PRECISION number {
            Dprintf("Gram: Precision %d bits\n", 8+$2);
            ((TransCtrl)global->batch_list->closure)->precision=$2;
        };

boolean      : BOOLEAN { $$ = $1; };

string : STRING {
        ptr = (char *)malloc(strlen($1)+1);
        strcpy(ptr, $1);
        ptr[strlen(ptr)-1] = '\0';
        $$ = ptr;

```



- 417 -

};

fnumber : FNUMBER { \$\$ = \$1; };

number : NUMBER { \$\$ = \$1; };

% %

yyerror(s) char \*s; {

Eprintf("Gram: error %s\n",s);

exit(3);

}

void NewBatch(proc,closure,call\_data)

Proc proc;

caddr\_t closure, call\_data;

{

Batch bat=(Batch)MALLOC(sizeof(BatchRec));

bat-&gt;proc=proc;

bat-&gt;closure=closure;

bat-&gt;call\_data=call\_data;

bat-&gt;next=global-&gt;batch\_list;

global-&gt;batch\_list=bat;

}

- 418 -

source/Klics.h

/\* Block size - no not change \*/

#define BLOCK 2

typedef int Block[BLOCK][BLOCK]; /\* small block \*/

/\* tokens \*/

#define TOKENS 15

#define ZERO\_STILL 0

#define NON\_ZERO\_STILL 1

#define BLOCK\_SAME 2

#define ZERO\_VID 3

#define BLOCK\_CHANGE 4

#define LOCAL\_ZERO 5

#define LOCAL\_NON\_ZERO 6

#define CHANNEL\_ZERO 7

#define CHANNEL\_NON\_ZERO 8

#define OCT\_ZERO 9

#define OCT\_NON\_ZERO 10

#define LPF\_ZERO 11

#define LPF\_NON\_ZERO 12

#define LPF\_LOC\_ZERO 13

#define LPF\_LOC\_NON\_ZERO 14

static int token\_bits[TOKENS]

={1,1,1,2,2,1,1,1,1,1,1,1,1,1,1};

static unsigned char token\_codes[TOKENS]={0,1,0,1,3,0,1,0,1,0,1,0,1,0,1};

- 419 -

/\* decision algorithms \*/

#define MAXIMUM 0

#define SIGABS 1

#define SIGSQR 2

/\* compression modes \*/

#define STILL 0

#define SEND 1

#define VOID 2

#define STOP 3

/\* LookAhead histogram \*/

#define HISTO 400

#define HISTO\_DELTA 20.0

#define HISTO\_BITS 9

#include "../include/Bits.h"

```
typedef struct {
    Video src, dst;
    Boolean stillvid, stats_switch, bin_switch, auto_q, buf_switch;
    double quant_const, thresh_const, cmp_const, fps,
           base_factors[5], diag_factor, chrome_factor;
    int bitrate, feedback, decide, filter;
    char name[STRLEN], stats_name[STRLEN], bin_name[STRLEN],
src_name[STRLEN];
    Bits bfp;
} CompCtrlRec, *CompCtrl;
```

```
typedef struct {
    Boolean stillvid, auto_q, buf_switch;
    double quant_const, thresh_const, cmp_const, fps,
```

- 420 -

```
        base_factors[5], diag_factor, chrome_factor;
    int    decide;
    VideoFormat type;
    Boolean    disk, gamma;
    int    rate, start, size[3], UVsample[2];
    VideoTrans    trans;
    int    precision;
} KlicsHeaderRec, *KlicsHeader;
```

- 421 -

## source/KlicsSA.h

```
#include <stdio.h>
#include      "Bits.h"

#define      negif(bool,value)    ((bool)?-(value):(value))

extern Bits  bopen();
extern void  bclose(), bread(), bwrite(), bflush();

/* Stand Alone definitions to replace VideoRec & CompCtrl assumes:
 *      video->type == YUV;
 *      video->UVsample[] = {1,1};
 *      video->trans.wavelet.space[] = {3,2};
 *      ctrl->bin_switch == True;
 */

#define SA_WIDTH      352
#define SA_HEIGHT     288
#define      SA_PRECISION      2
static double      base_factors[5] = {1.0,0.32,0.16,0.16,0.16};
#define      diag_factor      1.4142136
#define chrome_factor      2.0
#define      thresh_const  0.6
#define      cmp_const      0.9

/* Block size - no not change */
#define      BLOCK      2

typedef int Block[BLOCK][BLOCK]; /* small block */
```

- 422 -

/\* tokens \*/

#define TOKENS 15

#define ZERO\_STILL 0

#define NON\_ZERO\_STILL 1

#define BLOCK\_SAME 2

#define ZERO\_VID 3

#define BLOCK\_CHANGE 4

#define LOCAL\_ZERO 5

#define LOCAL\_NON\_ZERO 6

#define CHANNEL\_ZERO 7

#define CHANNEL\_NON\_ZERO 8

#define OCT\_ZERO 9

#define OCT\_NON\_ZERO 10

#define LPF\_ZERO 11

#define LPF\_NON\_ZERO 12

#define LPF\_LOC\_ZERO 13

#define LPF\_LOC\_NON\_ZERO 14

static int token\_bits[TOKENS]

={1,1,1,2,2,1,1,1,1,1,1,1,1,1};

static unsigned char token\_codes[TOKENS]={0,1,0,1,3,0,1,0,1,0,1,0,1,0,1};

/\* decision algorithms \*/

#define MAXIMUM 0

#define SIGABS 1

#define SIGSQR 2

/\* compression modes \*/

#define STILL 0

#define SEND 1

#define VOID 2

- 423 -

```
#define STOP 3
```

```
/* LookAhead histogram */
```

```
#define HISTO 400
```

```
#define HISTO_DELTA 20.0
```

```
#define HISTO_BITS 9
```

- 424 -

source/Lex.l

```
%{

/*
 *   Lex driver for input files: .pal .vid .bat
 */

#include    "../include/xwave.h"
#include    "../include/Gram.h"
extern int  ParseInput();

#undef      unput
#undef      input
#undef      output
#undef      feof
#define     unput(c)      ungetc(c,global->parse_fp)
#define     input()       ParseInput(global->parse_fp)
#define     output(c)     putchar(c)
#define     feof()        (1)

%}

number     -?[0-9]+
fnumber     -?[0-9]+ "." [0-9]+
string      \"([^\"]|\\.)*\

%start WAIT MAP VIDEO BATCH BATCH_TRANS BATCH_COMP
%n 2000
%p 4000
%e 2000
```



- 425 -

%%

```
"/*" { char c='\0';
```

```
    while(c!='/') {
        while (c!='*') c=input();
        while (c=='*') c=input();
    }
}
```

```
\.pal { BEGIN MAP; Dprintf("Lex: Reading palette file\n"); return(FILE_PAL); }
\.vid { BEGIN VIDEO; Dprintf("Lex: Reading video file\n"); return(FILE_VID); }
\.bat { BEGIN BATCH; Dprintf("Lex: Reading batch file\n"); return(FILE_BAT); }
```

```
{number}      { (void)sscanf(yytext, "%d", &yylval.num); return(NUMBER); }
{string}      { yylval.ptr = (char *)yytext; return(STRING); }
{fnumber}     { (void)sscanf(yytext, "%lf", &yylval.fnum); return(FNUMBER); }
```

```
<MAP> Palette { return(PALETTE); }
<MAP> \{      { return(LEFT_BRACE); }
<MAP> \}      { return(RIGHT_BRACE); }
<MAP> Range   { return(RANGE); }
<MAP> Line    { return(LINE); }
```

```
<VIDEO> Type   { return(TYPE); }
<VIDEO> MONO   { return(FORMAT_MONO); }
<VIDEO> RGB    { return(FORMAT_RGB); }
<VIDEO> YUV    { return(FORMAT_YUV); }
<VIDEO> Rate   { return(RATE); }
<VIDEO> Disk   { return(DISK); }
<VIDEO> Gamma  { return(GAMMA); }
<VIDEO> Negative { return(NEGATIVE); }
```

- 426 -

```
<VIDEO>Path          { return(PATH); }
<VIDEO>Files         { return(FILES); }
<VIDEO>Transform      { return(TRANSFORM); }
<VIDEO>None          { return(TRANSFORM_NONE); }
<VIDEO>Wavelet       { return(TRANSFORM_WAVE); }
<VIDEO>Start         { return(START); }
<VIDEO>End           { return(END); }
<VIDEO>Length        { return(LEN); }
<VIDEO>Dimensions     { return(DIM); }
<VIDEO>Header        { return(HEADER); }
<VIDEO>Offsets       { return(OFFSETS); }
<VIDEO>Size          { return(SIZE); }
<VIDEO>Precision      { return(PRECISION); }
<VIDEO>Yes           { yy1val.bool=True; return(BOOLEAN); }
<VIDEO>No            { yy1val.bool=False; return(BOOLEAN); }

<BATCH>Load          { return(LOAD); }
<BATCH>Save          { return(SAVE); }
<BATCH>SaveAbekus    { return(SAVE_ABEKUS); }
<BATCH>Compare       { return(COMPARE); }
<BATCH>Drop          { return(DROP); }
<BATCH>ImportKLICS   { return(IMPORT_KLICS); }
<BATCH>Transform      { BEGIN BATCH_TRANS; return(TRANSFORM); }
<BATCH>Compress       { BEGIN BATCH_COMP; return(COMPRESS); }
<BATCH>Xwave         { return(XWAVE); }
<BATCH>Shell         { return(SHELL); }
<BATCH>Copy          { return(COPY); }
<BATCH>Direct        { return(DIRECT_COPY); }
<BATCH>Diff          { return(DIFF); }
<BATCH>LPFzero       { return(LPF_WIPE); }
<BATCH>LPFonly       { return(LPF_ONLY); }
<BATCH>RGB-YUV       { return(RGB_YUV); }
```

- 427 -

<BATCH> Gamma { return(GAMMA); }

<BATCH\_COMP> VideoName { return(VIDEO\_NAME); }

<BATCH\_COMP> Stats { return(STATS\_NAME); }

<BATCH\_COMP> Binary { return(BIN\_NAME); }

<BATCH\_COMP> Yes { yy1val.bool=True; return(BOOLEAN); }

<BATCH\_COMP> No { yy1val.bool=False; return(BOOLEAN); }

<BATCH\_COMP> Still { return(STILL\_MODE); }

<BATCH\_COMP> Video { return(VIDEO\_MODE); }

<BATCH\_COMP> AutoQuant { return(AUTO\_Q); }

<BATCH\_COMP> QuantConst { return(QUANT\_CONST); }

<BATCH\_COMP> ThreshConst { return(THRESH\_CONST); }

<BATCH\_COMP> BaseFactor { return(BASE\_FACTOR); }

<BATCH\_COMP> DiagFactor { return(DIAG\_FACTOR); }

<BATCH\_COMP> ChromeFactor { return(CHROME\_FACTOR); }

<BATCH\_COMP> Decision { return(DECISION); }

<BATCH\_COMP> Feedback { return(FEEDBACK); }

<BATCH\_COMP> Maximum { return(DEC\_MAX); }

<BATCH\_COMP> SigmaAbs { return(DEC\_SIGABS); }

<BATCH\_COMP> SigmaSqr { return(DEC\_SIGSQR); }

<BATCH\_COMP> Filter { return(FILTER); }

<BATCH\_COMP> None { return(FLT\_NONE); }

<BATCH\_COMP> Exp { return(FLT\_EXP); }

<BATCH\_COMP> CmpConst { return(CMP\_CONST); }

<BATCH\_COMP> FrameRate { return(FPS); }

<BATCH\_COMP> Bitrate { return(BITRATE); }

<BATCH\_COMP> Buffer { return(BUFFER); }

<BATCH\_COMP> \{ { return(LEFT\_BRACE); }

<BATCH\_COMP> \} { END; BEGIN BATCH;

return(RIGHT\_BRACE); }

<BATCH\_TRANS> VideoName { return(VIDEO\_NAME); }

- 428 -

```
<BATCH_TRANS> Direction    { return(DIRECTION); }
<BATCH_TRANS> Space { return(SPACE); }
<BATCH_TRANS> Precision     { return(PRECISION); }
<BATCH_TRANS> Yes           { yy1val.bool=True; return(BOOLEAN); }
<BATCH_TRANS> No            { yy1val.bool=False; return(BOOLEAN); }
<BATCH_TRANS> \{            { return(LEFT_BRACE); }
<BATCH_TRANS> \}            { END; BEGIN BATCH; return(RIGHT_BRACE); }
```

```
[. \t\n]          { ; }
```

```
%%
```

```
yywrap() { return(1); }
```

- 429 -

## source/Transform.h

```
typedef struct {  
    Video src;  
    char  name[STRLEN], src_name[STRLEN];  
    int   space[2], precision;  
    Boolean dirn;  
} TransCtrlRec, *TransCtrl;
```

- 430 -

source/Video.h

```
typedef struct {  
    char  names[4][STRLEN];  
} AbekusCtrlRec, *AbekusCtrl;
```

- 431 -

## source/makefile

```

# Xwave Makefile
#
CFLAGS = -O -I../include
LIBS   = -lXaw -lXmu -lXt -lXext -lX11 -lm -ll -L/usr/openwin/lib

.KEEP_STATE:
.SUFFIXES: .c .o

xwaveSRC = Select.c Convert.c xwave.c InitMain.c Pop2.c Video2.c Malloc.c
InitFrame.c \
        Frame.c Transform.c Convolve3.c Update.c Image.c Menu.c
PullRightMenu.c \
        NameButton.c SmeBSBpr.c Process.c Lex.c Gram.c Parse.c Color.c \
        Bits.c Storage.c Copy.c Message.c Palette.c ImportKlics.c Icon3.c Klics5.c
\
        KlicsSA.c KlicsTestSA.c ImportKlicsSA.c ImpKlicsTestSA.c

objDIR = ../$(ARCH)

xwaveOBJ = $(xwaveSRC:%.c=$(objDIR)/%.o)

$(objDIR)/xwave: $(xwaveOBJ)
        gcc -o $@ $(xwaveOBJ) $(LIBS) $(CFLAGS)
        echo .....

$(xwaveOBJ): $$(@F:.o=.c) ../include/xwave.h
        gcc -c $(@F:.o=.c) $(CFLAGS) -o $@

Lex.c: Gram.c Lex.l

```

- 432 -

```
lex Lex.l
```

```
mv lex.yy.c Lex.c
```

```
Gram.c: Gram.y
```

```
bison -dlt Gram.y
```

```
mv $(@F:.c=.tab.h) ../include/Gram.h
```

```
mv $(@F:.c=.tab.c) Gram.c
```



- 433 -

**include/Bits.h**

#ifndef \_Bits\_h

#define \_Bits\_h

```
typedef struct {
    unsigned char buf;
    int bufsize;
    FILE *fp;
} BitsRec, *Bits;
```

#endif

- 434 -

include/DTheader.h

```
typedef struct DTheader {
    char file_id[8];          /* "DT-IMAGE" */
    char struct_id;           /* 1 */
    char prod_id;             /* 4 */
    char util_id;             /* 1 */
    char board_id;            /* 2 */
    char create_time[9]; /* [0-1]year, [2]month, [3]dayofmonth, [4]dayofweek,
[5]hour, [6]min, [7]sec, [8]sec/100 */
    char mod_time[9];         /* as create_time */
    char datum;               /* 1 */
    char datasize[4];         /* 1024?? */
    char file_struct;         /* 1 */
    char datatype;            /* 1 */
    char compress;            /* 0 */
    char store;               /* 1 */
    char aspect[2];           /* 4, 3 */
    char bpp;                 /* 8 */
    char spatial;             /* 1 */
    char width[2];            /* 512 */
    char height[2];           /* 512 */
    char full_width[2];       /* 512 */
    char full_height[2];      /* 512 */
    char unused1[45];
    char comment[160];
    char unused2[256];
} DTheader;
```

- 435 -

**include/Icon.h**

```
typedef      enum {  
    FW_label, FW_icon, FW_command, FW_text, FW_button, FW_icon_button,  
    FW_view, FW_toggle,  
    FW_yn,  
    FW_up, FW_down, FW_integer,  
    FW_scroll, FW_float,  
    FW_form,  
} FormWidgetType;
```

```
typedef      enum {  
    SW_below, SW_over, SW_top, SW_menu,  
} ShellWidgetType;
```

```
typedef      struct {  
    String name;  
    String contents;  
    int      fromHoriz, fromVert;  
    FormWidgetType type;  
    String hook;  
} FormItem;
```

- 436 -

include/Image.h

/\*

\* \$XConsortium: Image.h,v 1.24 89/07/21 01:48:51 kit Exp \$

\*/

/\*\*\*\*\*

Copyright 1987, 1988 by Digital Equipment Corporation, Maynard, Massachusetts,  
and the Massachusetts Institute of Technology, Cambridge, Massachusetts.

All Rights Reserved

Permission to use, copy, modify, and distribute this software and its  
documentation for any purpose and without fee is hereby granted,  
provided that the above copyright notice appear in all copies and that  
both that copyright notice and this permission notice appear in  
supporting documentation, and that the names of Digital or MIT not be  
used in advertising or publicity pertaining to distribution of the  
software without specific, written prior permission.

DIGITAL DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS SOFTWARE,  
INCLUDING

ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS, IN NO  
EVENT SHALL

DIGITAL BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL  
DAMAGES OR

ANY DAMAGES WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR  
PROFITS,

WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR OTHER  
TORTIOUS ACTION,

- 437 -

ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF  
THIS  
SOFTWARE.

\*\*\*\*\*/

#ifndef \_XawImage\_h

#define \_XawImage\_h

\*\*\*\*\*/

\*

\* Image Widget

\*

\*\*\*\*\*/

#include <X11/Xaw/Simple.h>

#include <X11/Xmu/Converters.h>

/\* Resources:

Name	Class	RepType	Default Value
border	BorderColor	Pixel	XtDefaultForeground
borderWidth	BorderWidth	Dimension	1
cursor	Cursor	Cursor	None
destroyCallback	Callback	XtCallbackList	NULL
insensitiveBorder	Insensitive	Pixmap	Gray
mappedWhenManaged	MappedWhenManaged	Boolean	True
sensitive	Sensitive	Boolean	True
bitmap	Bitmap	Pixmap	NULL
callback	Callback	XtCallbackList	NULL
x	Position	Position	0

- 438 -

y                    Position            Position            0

\*/

#define XtNbbitmap    "bitmap"

#define XtCBitmap    "Bitmap"

/\* Class record constants \*/

extern WidgetClass imageWidgetClass;

typedef struct \_ImageClassRec \*ImageWidgetClass;

typedef struct \_ImageRec       \*ImageWidget;

#endif /\* \_XawImage\_h \*/

/\* DON'T ADD STUFF AFTER THIS #endif \*/

- 439 -

```
include/ImageHeader.h
```

```
/* Author: Philip R. Thompson
 * Address: phils@athena.mit.edu, 9-526
 * Note: size of header should be 1024 (1K) bytes.
 * $Header: ImageHeader.h,v 1.2 89/02/13 09:01:36 phils Locked $
 * $Date: 89/02/13 09:01:36 $
 * $Source: /mit/phils/utils/RCS/ImageHeader.h,v $
 */

#define IMAGE_VERSION 3

typedef struct ImageHeader {
    char file_version[8]; /* header version */
    char header_size[8]; /* Size of file header in bytes */
    char image_width[8]; /* Width of the raster image */
    char image_height[8]; /* Height of the raster image */
    char num_colors[8]; /* Actual number of entries in c_map */
    char num_channels[8]; /* 0 or 1 = pixmap, 3 = RG&B buffers */
    char num_pictures[8]; /* Number of pictures in file */
    char alpha_channel[4]; /* Alpha channel flag */
    char runlength[4]; /* Runlength encoded flag */
    char author[48]; /* Name of who made it */
    char date[32]; /* Date and time image was made */
    char program[16]; /* Program that created this file */
    char comment[96]; /* other viewing info. for this image */
    unsigned char c_map[256][3]; /* RGB values of the pixmap indices */
} ImageHeader;

/* Note:
 * - All data is in char's in order to maintain easily portability
```

- 440 -

- \* across machines and some human readability.
- \* - Images may be stored as pixmaps or in separate channels, such as
- \* red, green, blue data.
- \* - An optional alpha channel is separate and is found after every
- \* num\_channels of data.
- \* - Pixmaps, red, green, blue, alpha and other channel data are stored
- \* sequentially after the header.
- \* - If num\_channels = 1 or 0, a pixmap is assumed and up to num\_colors
- \* of colormap in the header are used.
- \*/

/\*\*\*/ end ImageHeader.h \*/



- 441 -

include/ImageP.h

/\*

\* \$XConsortium: ImageP.h,v 1.24 89/06/08 18:05:01 swick Exp \$

\*/

/\*\*\*\*\*\*

Copyright 1987, 1988 by Digital Equipment Corporation, Maynard, Massachusetts,  
and the Massachusetts Institute of Technology, Cambridge, Massachusetts.

All Rights Reserved

Permission to use, copy, modify, and distribute this software and its  
documentation for any purpose and without fee is hereby granted,  
provided that the above copyright notice appear in all copies and that  
both that copyright notice and this permission notice appear in  
supporting documentation, and that the names of Digital or MIT not be  
used in advertising or publicity pertaining to distribution of the  
software without specific, written prior permission.

DIGITAL DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS SOFTWARE,  
INCLUDING

ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS, IN NO  
EVENT SHALL

DIGITAL BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL  
DAMAGES OR

ANY DAMAGES WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR  
PROFITS,

WHETHER IN AN ACTION OF CONTRACT, NEGLIGENCE OR OTHER

- 442 -

TORTIOUS ACTION,  
ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF  
THIS  
SOFTWARE.

```

*****/

/*
 * ImageP.h - Private definitions for Image widget
 *
 */

#ifndef _XawImageP_h
#define _XawImageP_h

/*****
 *
 * Image Widget Private Data
 *
 *****/

#include "../include/Image.h"
#include <X11/Xaw/SimpleP.h>

/* New fields for the Image widget class record */

typedef struct {int foo;} ImageClassPart;

/* Full class record declaration */
typedef struct _ImageClassRec {
    CoreClassPart    core_class;
    SimpleClassPart  simple_class;

```

- 443 -

```

    ImageClassPart  image_class;
} ImageClassRec;

```

```

extern ImageClassRec imageClassRec;

```

```

/* New fields for the Image widget record */

```

```

typedef struct {

```

```

    /* resources */

```

```

    Pixmap      pixmap;

```

```

    XtCallbackList  callbacks;

```

```

    /* private state */

```

```

    Dimension    map_width, map_height;

```

```

} ImagePart;

```

```

/*****

```

```

 *

```

```

 * Full instance record declaration

```

```

 *

```

```

*****/

```

```

typedef struct _ImageRec {

```

```

    CorePart  core;

```

```

    SimplePart  simple;

```

```

    ImagePart  image;

```

```

} ImageRec;

```

```

#endif /* _XawImageP_h */

```

- 444 -

**include/Message.h**

```
typedef      struct {  
    Widget      shell, widget; /* shell and text widgets (NULL if not created */  
    XawTextBlock      info; /* Display text */  
    int      size, rows, cols; /* Size of buffer (info.ptr) & dimensions of display */  
    XawTextEditType      edit; /* edit type */  
    Boolean      own_text; /* text is owned by message? */  
} MessageRec, *Message;
```

- 445 -

**include/Palette.h**

#define PalettePath "."

#define PaletteExt ".pal"

```
typedef struct _MapRec {
    int start, finish, m, c;
    struct _MapRec *next;
} MapRec, *Map;
```

```
typedef struct _PaletteRec {
    char name[STRLEN];
    Map mappings;
    struct _PaletteRec *next;
} PaletteRec, *Palette;
```

- 446 -

include/PullRightMenu.h

/\*

\* \$XConsortium: PullRightMenu.h,v 1.17 89/12/11 15:01:55 kit Exp \$

\*

\* Copyright 1989 Massachusetts Institute of Technology

\*

\* Permission to use, copy, modify, distribute, and sell this software and its  
\* documentation for any purpose is hereby granted without fee, provided that  
\* the above copyright notice appear in all copies and that both that  
\* copyright notice and this permission notice appear in supporting  
\* documentation, and that the name of M.I.T. not be used in advertising or  
\* publicity pertaining to distribution of the software without specific,  
\* written prior permission. M.I.T. makes no representations about the  
\* suitability of this software for any purpose. It is provided "as is"  
\* without express or implied warranty.

\*

\* M.I.T. DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS SOFTWARE,  
INCLUDING ALL

\* IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS, IN NO  
EVENT SHALL M.I.T.

\* BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES  
OR ANY DAMAGES

\* WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS,  
WHETHER IN AN ACTION

\* OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS ACTION, ARISING OUT  
OF OR IN

\* CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.

\*

\*/

- 447 -

```

/*
 * PullRightMenu.h - Public Header file for PullRightMenu widget.
 *
 * This is the public header file for the Athena PullRightMenu widget.
 * It is intended to provide one pane pulldown and popup menus within
 * the framework of the X Toolkit. As the name implies it is a first and
 * by no means complete implementation of menu code. It does not attempt to
 * fill the needs of all applications, but does allow a resource oriented
 * interface to menus.
 *
 */

```

```

#ifndef _PullRightMenu_h
#define _PullRightMenu_h

```

```

#include <X11/Shell.h>
#include <X11/Xmu/Converters.h>

```

```

/*****
 *
 * PullRightMenu widget
 *
 *****/

```

```

/* PullRightMenu Resources:

```

Name	Class	RepType	Default Value
background	Background	Pixel	XtDefaultBackground
backgroundPixmap	BackgroundPixmap	Pixmap	None
borderColor	BorderColor	Pixel	XtDefaultForeground
borderPixmap	BorderPixmap	Pixmap	None

- 448 -

borderWidth	BorderWidth	Dimension	1
bottomMargin	VerticalMargins	Dimension	VerticalSpace
columnWidth	ColumnWidth	Dimension	Width of widest text
cursor	Cursor	Cursor	None
destroyCallback	Callback	Pointer	NULL
height	Height	Dimension	0
label	Label	String	NULL (No label)
labelClass	LabelClass	Pointer	smeBSBObjectClass
mappedWhenManaged	MappedWhenManaged	Boolean	True
rowHeight	RowHeight	Dimension	Height of Font
sensitive	Sensitive	Boolean	True
topMargin	VerticalMargins	Dimension	VerticalSpace
width	Width	Dimension	0
button	Widget	Widget	NULL
x	Position	Position	0
y	Position	Position	0

\*/

```
typedef struct _PullRightMenuClassRec* PullRightMenuWidgetClass;
typedef struct _PullRightMenuRec* PullRightMenuWidget;
```

```
extern WidgetClass pullRightMenuWidgetClass;
```

```
#define XtNcursor "cursor"
#define XtNbottomMargin "bottomMargin"
#define XtNcolumnWidth "columnWidth"
#define XtNlabelClass "labelClass"
#define XtNmenuOnScreen "mcnuOnScreen"
#define XtNpopupOnEntry "popupOnEntry"
#define XtNrowHeight "rowHeight"
#define XtNtopMargin "topMargin"
```



- 449 -

```
#define XtNbutton    "button"
```

```
#define XtCColumnWidth "ColumnWidth"
```

```
#define XtCLabelClass "LabelClass"
```

```
#define XtCMenuOnScreen "MenuOnScreen"
```

```
#define XtCPopupOnEntry "PopupOnEntry"
```

```
#define XtCRowHeight "RowHeight"
```

```
#define XtCVerticalMargins "VerticalMargins"
```

```
#define      XtCWidget    "Widget"
```

```
/*
 *
 * Public Functions.
 *
 */
```

```
*****/
```

```
/*      Function Name: XawPullRightMenuAddGlobalActions
 *      Description: adds the global actions to the simple menu widget.
 *      Arguments: app_con - the appcontext.
 *      Returns: none.
 */
```

```
void
```

```
XawpullRightMenuAddGlobalActions(/* app_con */);
```

```
/*
```

```
XtAppContext app_con;
```

```
*/
```

```
#endif /* _PullRightMenu_h */
```

- 450 -

include/SmeBSBpr.h

/\*

\* \$XConsortium: SmeBSB.h,v 1.5 89/12/11 15:20:14 kit Exp \$

\*

\* Copyright 1989 Massachusetts Institute of Technology

\*

\* Permission to use, copy, modify, distribute, and sell this software and its  
\* documentation for any purpose is hereby granted without fee, provided that  
\* the above copyright notice appear in all copies and that both that  
\* copyright notice and this permission notice appear in supporting  
\* documentation, and that the name of M.I.T. not be used in advertising or  
\* publicity pertaining to distribution of the software without specific,  
\* written prior permission. M.I.T. makes no representations about the  
\* suitability of this software for any purpose. It is provided "as is"  
\* without express or implied warranty.

\*

\* M.I.T. DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS SOFTWARE,  
INCLUDING ALL

\* IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS, IN NO  
EVENT SHALL M.I.T.

\* BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES  
OR ANY DAMAGES

\* WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS,  
WHETHER IN AN ACTION

\* OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS ACTION, ARISING OUT  
OF OR IN

\* CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.

\*/

- 451 -

/\*

\* SmeBSBpr.h - Public Header file for SmeBSB object.

\*

\* This is the public header file for the Athena BSB Sme object.

\* It is intended to be used with the simple menu widget. This object

\* provides bitmap - string - bitmap style entries.

\*

\*/

#ifndef \_SmeBSBpr\_h

#define \_SmeBSBpr\_h

#include &lt;X11/Xmu/Converters.h&gt;

#include &lt;X11/Xaw/Sme.h&gt;

/\*\*\*\*\*

\*

\* SmeBSBpr object

\*

\*\*\*\*\*/

/\* BSB pull-right Menu Entry Resources:

Name	Class	RepType	Default Value
callback	Callback	Callback	NULL
destroyCallback	Callback	Pointer	NULL
font	Font	XFontStruct *	XtDefaultFont
foreground	Foreground	Pixel	XtDefaultForeground
height	Height	Dimension	0
label	Label	String	Name of entry

- 452 -

leftBitmap	LeftBitmap	Pixmap	None
leftMargin	HorizontalMargins	Dimension	4
rightBitmap	RightBitmap	Pixmap	None
rightMargin	HorizontalMargins	Dimension	4
sensitive	Sensitive	Boolean	True
vertSpace	VertSpace	int	25
width	Width	Dimension	0
x	Position	Position	0n
y	Position	Position	0
menuName	MenuName	String	"menu"

\*/

typedef struct \_SmeBSBprClassRec \*SmeBSBprObjectClass;

typedef struct \_SmeBSBprRec \*SmeBSBprObject;

extern WidgetClass smeBSBprObjectClass;

#define XtNleftBitmap "leftBitmap"

#define XtNleftMargin "leftMargin"

#define XtNrightBitmap "rightBitmap"

#define XtNrightMargin "rightMargin"

#define XtNvertSpace "vertSpace"

#define XtNmenuName "menuName"

#define XtCLeftBitmap "LeftBitmap"

#define XtCHorizontalMargins "HorizontalMargins"

#define XtCRightBitmap "RightBitmap"

#define XtCVertSpace "VertSpace"

#define XtCMenuName "MenuName"

#endif /\* \_SmeBSBpr\_h \*/

- 453 -

include/SmeBSBprP.h

/\*

\* \$XConsortium: SmeBSBP.h,v 1.6 89/12/11 15:20:15 kit Exp \$

\*

\* Copyright 1989 Massachusetts Institute of Technology

\*

\* Permission to use, copy, modify, distribute, and sell this software and its  
\* documentation for any purpose is hereby granted without fee, provided that  
\* the above copyright notice appear in all copies and that both that  
\* copyright notice and this permission notice appear in supporting  
\* documentation, and that the name of M.I.T. not be used in advertising or  
\* publicity pertaining to distribution of the software without specific,  
\* written prior permission. M.I.T. makes no representations about the  
\* suitability of this software for any purpose. It is provided "as is"  
\* without express or implied warranty.

\*

\* M.I.T. DISCLAIMS ALL WARRANTIES WITH REGARD TO THIS SOFTWARE,  
INCLUDING ALL

\* IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS, IN NO  
EVENT SHALL M.I.T.

\* BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES  
OR ANY DAMAGES

\* WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS,  
WHETHER IN AN ACTION

\* OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS ACTION, ARISING OUT  
OF OR IN

\* CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.

\*

\* Author: Chris D. Peterson, MIT X Consortium

- 454 -

```
*/

/*
 * SmeP.h - Private definitions for Sme object
 *
 */

#ifndef _XawSmeBSBP_h
#define _XawSmeBSBP_h

/*****
 *
 * Sme Object Private Data
 *
 *****/

#include <X11/Xaw/SmeP.h>
#include "../include/SmeBSBpr.h"

/*****
 *
 * New fields for the Sme Object class record.
 *
 *****/

typedef struct _SmeBSBprClassPart {
    XtPointer extension;
} SmeBSBprClassPart;

/* Full class record declaration */
typedef struct _SmeBSBprClassRec {
    RectObjClassPart    rect_class;
```

- 455 -

```

SmeClassPart    sme_class;
SmeBSBprClassPart sme_bsb_class;
} SmeBSBprClassRec;

```

```

extern SmeBSBprClassRec smeBSBprClassRec;

```

```

/* New fields for the Sme Object record */

```

```

typedef struct {

```

```

    /* resources */

```

```

    String label;          /* The entry label. */

```

```

    int vert_space;        /* extra vert space to leave, as a percentage
                           of the font height of the label. */

```

```

    Pixmap left_bitmap, right_bitmap; /* bitmaps to show. */

```

```

    Dimension left_margin, right_margin; /* left and right margins. */

```

```

    Pixel foreground;      /* foreground color. */

```

```

    XFontStruct * font;    /* The font to show label in. */

```

```

    XtJustify justify;     /* Justification for the label. */

```

```

    String menu_name; /* Popup menu name */

```

```

/* private resources. */

```

```

    Boolean set_values_area_cleared; /* Remember if we need to unhighlight. */

```

```

    GC norm_gc;          /* normal color gc. */

```

```

    GC rev_gc;           /* reverse color gc. */

```

```

    GC norm_gray_gc;     /* Normal color (grayed out) gc. */

```

```

    GC invert_gc;        /* gc for flipping colors. */

```

```

    Dimension left_bitmap_width; /* size of each bitmap. */

```

```

    Dimension left_bitmap_height;

```

```

    Dimension right_bitmap_width;

```

```

    Dimension right_bitmap_height;

```

- 456 -

```
} SmeBSBprPart;
```

```
/******
```

```
*
```

```
* Full instance record declaration
```

```
*
```

```
*****/
```

```
typedef struct _SmeBSBprRec {
```

```
    ObjectPart      object;
```

```
    RectObjPart     rectangle;
```

```
    SmePart         sme;
```

```
    SmeBSBprPart    sme_bsb;
```

```
} SmeBSBprRec;
```

```
/******
```

```
*
```

```
* Private declarations.
```

```
*
```

```
*****/
```

```
#endif /* _XawSmeBSBPpr_h */
```



- 457 -

**include/xwave.h**

```
#include    <X11/Xlib.h>
#include    <X11/Xutil.h>
#include    <X11/Xatom.h>
#include    <X11/Xaw/Cardinals.h>
#include    <X11/StringDefs.h>
#include    <X11/Xmu/Xmu.h>
#include    <X11/Xaw/Command.h>
#include    <X11/Xaw/List.h>
#include    <X11/Xaw/Box.h>
#include    <X11/Xaw/Form.h>
#include    <X11/Xaw/Scrollbar.h>
#include    <X11/Xaw/Viewport.h>
#include    <X11/Xaw/AsciiText.h>
#include    <X11/Xaw/Dialog.h>
#include    <X11/Xaw/MenuButton.h>
#include    <X11/Xaw/SimpleMenu.h>
#include    <X11/Xaw/SmeBSB.h>
#include    <X11/Xaw/Toggle.h>
#include    "SmeBSBpr.h"
#include    "PullRightMenu.h"
#include    <X11/Shell.h>
#include    <X11/cursorfont.h>
#define     STRLEN      100
#define     NAME_LEN    20
#include    "Image.h"
#include    "Message.h"
#include    <dirent.h>
#include    <math.h>
```

- 458 -

```
#include    <stdio.h>
#include    "Palette.h"
#include    "Icon.h"

#define     PLOT_DIR    "graphs"
#define     PLOT_EXT    ".plot"
#define     ELLA_IN_DIR    "."
#define     ELLA_IN_EXT    ".eli"
#define     ELLA_OUT_DIR    "."
#define     ELLA_OUT_EXT    ".elo"
#define     VID_DIR    "videos"
#define     VID_EXT    ".vid"
#define     IMAGE_DIR    "images"
#define     BATCH_DIR    "batch"
#define     BATCH_EXT    ".bat"
#define     KLICS_DIR    "import"
#define     KLICS_EXT    ".klics"
#define     KLICS_SA_DIR    "import"
#define     KLICS_SA_EXT    ".klicsSA"

typedef enum {
    TRANS_None, TRANS_Wave,
} TransType;

typedef     enum {
    MONO, RGB, YUV,
} VideoFormat;

extern String ChannelName[3][4];

#define     negif(bool,value)    ((bool)?-(value):(value))
```

- 459 -

```
typedef      struct {
    String name;
    Pixmap    pixmap;
    unsigned int height, width;
} IconRec, *Icon;
```

```
typedef      void    (*Proc)();
typedef      String  *(*ListProc)();
typedef      Boolean  (*BoolProc)();
```

```
typedef      struct {
    String name;
    WidgetClass widgetClass;
    String label;
    String hook; /* menuName for smeBSBprObjectClass */
} MenuItem;
```

```
typedef      struct {
    String name, button;
    ListProc  list_proc;
    String action_name;
    Proc      action_proc;
    caddr_t   action_closure;
} SelectItem, *Selection;
```

```
typedef      struct {
    TransType type;
    int      space[2];
    Boolean   dirn;
} WaveletTrans;
```

```
typedef      union {
```

- 460 -

```

    TransType    type;
    WaveletTrans    wavelet;
} VideoTrans;

typedef    struct    _VideoRec    {
    char    name[STRLEN];                /* Name of this video name.vid */
    char    path[STRLEN];                /* Path to frame file(s) */
    char    files[STRLEN];                /* Name of frames files001 if not name */
    VideoFormat    type;                /* Type of video (MONO,RGB,YUV) */
    Boolean    disk;    /* Frames reside on disk rather than in memory */
    Boolean    gamma;                /* Gamma corrected flag */
    Boolean    negative;                /* Load negative values in data */
    int    rate;                /* Frames per second */
    int    start;                /* Starting frame number */
    int    size[3];    /* Dimensions of video after extraction x, y and z */
    int    UVsample[2];                /* Chrominance sub-sampling x and y */
    int    offset;                /* Header length */
    int    cols, rows;                /* Dimensions of video as stored */
    int    x_offset, y_offset;    /* Offset of extracted video in stored */
    VideoTrans    trans;                /* Transform technique used */
    int    precision;                /* Storage precision above 8 bits */
    short    **data[3];                /* Image data channels */
    struct    _VideoRec    *next;                /* Next video in list */
} VideoRec, *Video;

typedef    struct    {
    Video    video;
    char    name[STRLEN];
} VideoCtrlRec, *VideoCtrl;

typedef    struct    _PointRec    {
    int    location[2];

```

- 461 -

```
    int    usage;
    struct _PointRec    *next;
} PointRec, *Point;

typedef    struct _FrameRec    {
    Widget    shell, image_widget, point_merge_widget;
    Video video;
    int    zoom, frame, channel, palette;
    Boolean    point_switch, point_merge;
    Point point;
    Message    msg;
    struct _FrameRec    *next;
} FrameRec, *Frame;

#define    NO_CMAPS 6

typedef    struct _BatchRec    {
    Proc    proc;
    caddr_t    closure, call_data;
    struct _BatchRec    *next;
} BatchRec, *Batch;

typedef    struct {
    char    home[STRLEN];
    XtAppContext    app_con;
    Widget    toplevel;
    int    no_icons;
    Icon    icons;
    Video videos;
    Frame frames;
    Point points;
    Palette    palettes;
```

- 462 -

```
int    no_pals;
String parse_file;
String parse_token;
FILE   *parse_fp;
XVisualInfo *visinfo;
int    levels, rgb_levels, yuv_levels[3];
Colormap  cmaps[NO_CMAPS];
String batch;
Batch batch_list;
Boolean  debug;
int    dither[16][16];
} GlobalRec, *Global;
```

```
typedef struct {
    Widget    widgets[3];
    int    max, min, *value;
    String format;
} NumInputRec, *NumInput;
```

```
typedef struct {
    Widget    widgets[2];
    double    max, min, *value;
    String format;
} FloatInputRec, *FloatInput;
```

```
extern Global    global;
```

```
/* InitFrame.c */
```

```
extern Video FindVideo();
```

```
/* Pop2.c */
```

- 463 -

```
extern void  NA();
extern Widget FindWidget();
extern void  Destroy();
extern void  Free();
```

```
/* Storage.c */
```

```
extern void  NewFrame();
extern void  GetFrame();
extern void  SaveFrame();
extern void  FreeFrame();
extern void  SaveHeader();
extern Video CopyHeader();
```

```
/* Message.c */
```

```
extern void  TextSize();
extern Message NewMessage();
extern void  MessageWindow();
extern void  CloseMessage();
extern void  Mprintf();
extern void  Dprintf();
extern void  Eprintf();
extern void  Mflush();
```

```
/* Icon3.c */
```

```
extern void  FillForm();
extern void  FillMenu();
extern Widget ShellWidget();
extern Widget FormatWidget();
extern void  SimpleMenu();
```

- 464 -

```
extern int    TextWidth();
extern Icon   FindIcon();
extern void   NumIncDec();
extern void   FloatIncDec();
extern void   ChangeYN();
extern XFontStruct *FindFont();
```



- 465 -

DATA COMPRESSION AND DECOMPRESSION  
GREGORY KNOWLES AND ADRIAN S. LEWIS

M-2357 US

APPENDIX B-1

- 466 -

```

MAC_ADDR_COUNTER_COL = (bool:ck,t_reset:reset,STRING[xsize]bit:block_cnt_length)
->
(t_col,bool):
BEGIN
MAKE BASE_COUNTER_COL:base_counter_col.
JOIN (ck,reset,block_cnt_length) ->base_counter_col.

OUTPUT (base_counter_col[1], CASE base_counter_col[2]
      OF
      ELSE f
      ESAC)
count_carry:t

END.

MAC_ADDR_COUNTER_ROW = (bool:ck,t_reset:reset,STRING[ysize]bit:block_cnt_length,bool:col_carry)
->
(t_row,bool):
BEGIN
MAKE BASE_COUNTER_ROW:base_counter_row.
JOIN (ck,reset,col_carry,block_cnt_length,CASE col_carry #type conversion#
      OF t:count_carry
      ELSE count_rst
      ESAC) ->base_counter_row.

OUTPUT (base_counter_row[1], CASE base_counter_row[2]
      OF count_carry:t
      ELSE f
      ESAC)

END.

#the string base address calculators#

```

- 467 -

```

MAC NOMULT_MAC_READ = (bool:ck,t_reset:reset,bool:col_end,t_mux4:mux_control,STRING[17]bit:incr,
  STRING[17]bit:oct_add_factor, STRING[19]bit:base_u base_v)
->
  STRING[19]bit:
    BEGIN
      MAKE ADD_US_ACTEL[19,17]:add,
        MUX_2[STRING[17]bit]:mux.

    LET
      next_addr = MUX_4[STRING[19]bit](add[2..20],ZERO[19]b"0",base_u,base_v,mux_control),
      dff = DFF_NO_LOAD[STRING[19]bit](ck,reset,next_addr,b"00000000000000000000").

    JOIN (dff,mux,b'1) ->add,
      (incr,oct_add_factor,CASE col_end
        OF t:right
        ELSE left
        ESAC)
      ->mux.

    OUTPUT dff
    END.

    MAC S_SPA =(STRING[19]bit:in)
    ->
      (flag,t_sparc_addr):BIOP TRANSFORM_US.
    MAC SPA_S =(t_sparc_addr:in)
    ->
      (flag,STRING[19]bit):BIOP TRANSFORM_US.

    MAC SPARC_ADDR= (bool:ck,t_reset:reset,bool:col_end,t_mux4:mux_control,[2]t_sparc_addr:oct_add_factor,

```

- 468 -

```

        STRING[19]bit:base_u_base_v)
        ->
        t_sparc_addr:

BEGIN
    LET out=NOMULT_MAC_READ(ck,reset,col_end,mux_control,(SPA_S oct_add_factor[1])[2][3..19],
        (SPA_S oct_add_factor[2])[2][3..19],base_u_base_v).
    OUTPUT (S_SPA out)[2]
END.

#-----#

#the read and write address generator,input the initial image & block sizes for oct/0 at that channel#
FN ADDR_GEN_NOSCRATCH= (bool:ck,t_reset:reset,t_direction:direction,t_channel:channel,
    STRING[9]bit:x_p_1,STRING[11]bit:x3_p_1,STRING[12]bit:x7_p_1,
    STRING [ysize]bit:octave_row_length,STRING [xsize]bit:octave_col_length,t_reset:octave_reset,
    t_octave:octave,bool:y_done,bool:uv_done,t_load:octave_finished,STRING [19]bit:base_u_base_v)

    ->
    ((t_input_mux,t_sparcport,t_dwtport#dwt#),t_load#IDWT data valid#,t_load#read_valid#
        ,t_count_control#row read col read#,(t_col,t_count_control)#addr_col_read#):

#the current octave and when the block finishes the 3 octave transform#
BEGIN

#   ADDR_COUNTER_ROW:addr_row_write,#
#   ADDR_COUNTER_COL:addr_col_write,#
MAKE   ROW_COUNT_CARRY:addr_row_read,
        COL_COUNT:      addr_col_read,
        SPARC_ADDR:write_addr_read_addr,
        MEM_CONTROL_NOSCRATCH:mem_control,

```

#write begins #

JKFF:zero\_hh\_bool\_read\_done\_bool.

```

LET  mem_sel
      = CASE octave
      OF  oct/0:uno,
          oct/1:dos,
          oct/2:tres,
          oct/3:quatro
      ESAC,

      sparc_add_1
      = MUX_4(t_sparc_addr){
        (addr/1),
        (addr/2),
        (addr/4),
        (addr/8),
        mem_sel),

      sparc_add_2_y
      = MUX_4{STRING[12]bit}(
        (b"00000000000001"),
        (b"000" CONC x_p_1[1..7] CONC b"10"),
        (b"0" CONC x3_p_1[1..8] CONC b"100"),
        (x7_p_1[1..8] CONC b"1000"),
        mem_sel),

      sparc_add_2_uv
      = MUX_4{STRING[12]bit}(
        (b"00000000000001"),
        (b"0000" CONC x_p_1[1..6] CONC b"10"),
        (b"00" CONC x3_p_1[1..7] CONC b"100"),
        (b"0" CONC x7_p_1[1..7] CONC b"1000"),
        mem_sel),

      sparc_add_2
      = MUX_2{STRING[12]bit}( sparc_add_2_y, sparc_add_2_uv, CASE channel

```

- 470 -

OF y:left  
ELSE right  
ESAC),

sparc\_oct\_add\_factor = (sparc\_add\_1[S\_SPA(b'00000000" CONC sparc\_add\_2)](2)).

#signals when write must start delayed 1 tu for use in zero\_hh#

addr\_col\_read\_flag = CASE addr\_col\_read[2]#decode to bool#  
OF count\_carry:1  
ELSE 1  
ESAC,

write\_latency = CASE (addr\_row\_read[1], addr\_col\_read[1])  
OF (row/2,col/(conv2d\_latency-1)):1  
ELSE 1  
ESAC,

read\_done = CASE (addr\_row\_read[2], addr\_col\_read\_flag) #read input data done#  
OF (count\_carry,1):1  
ELSE 1  
ESAC,

zero\_hh = CAST(!\_load)/(NOT zero\_hh\_bool),

read\_valid = CAST(!\_load)/(NOT read\_done\_bool),

start\_write\_col = DFF\_NO\_LOAD(!\_load)(ck,reset,zero\_hh,read), #1 tu after zero\_hh#

- 471 -

```

read_mux = CASE (y_done,uv_done,octave_finished,channel)
OF (t,f,write,y)((f,f,write,u):tres, #base_u#
(f,t,write,u)((f,f,write,v):quatro, #base_v#
(f,bool,write,y):dos #base_y#
ELSE uno
ESAC,

```

```

write_mux = CASE zero_hh
OF write: uno,
read: CASE channel
OF y:dos, #base_y#
u:tres, #base_u#
v:quatro #base_v#
ESAC
ESAC.

```

JOIN

#note that all the counters have to be reset at the end of an octave, ie on octave\_finished#

```

(ck,octave_reset,octave_col_length) ->addr_col_read, #the row&col counts for the read address#
(ck,octave_reset,octave_row_length,addr_col_read[2]) ->addr_row_read,

```

```

(ck,octave_reset,write_latency,t) ->zero_hh_bool,

```

```

(ck,octave_reset,read_done,t) ->read_done_bool,

```

#w&amp;r addresses for sparc mem#

```

(ck,reset,PDF1{bool,conv2d_latency-1})(ck,reset,addr_col_read_flag,f),write_mux,sparc_oct_add_factor,base_u,base_v)
->write_addr,

```

```
(ck,reset,addr_col_read_flag,read_mux,sparc_oct_add_factor,base_u,base_v) ->read_addr,
```

```
(ck,reset,direction,channel,octave,write_addr,read_addr,zero_hh)->mem_control.
```

```
OUTPUT( mem_control,zero_hh, read_valid,addr_row_read[2],addr_col_read)
END.
```

```
#the basic 2d convolver for transform, rows first then cols.#
```

```
FN CONV_2D = (bool:ck,t_reset:reset,t_input:in,t_direction:direction,[4]t_scratch:pdcl,
```

```
t_reset:conv_reset,t_count_control:row_flag,(t_col,t_count_control):addr_col_read)
->
```

```
(t_input,t_memport,t_count_control,t_count_control,t_count_control):
```

```
#forward direction outputs in row form #
# HH HG HH HG ..... #
# HG GG HG GG ..... #
# HH HG HH HG ..... #
# HG GG HG GG ..... #
```

```
#the inverse convolver returns the raster scan format output data#
```

```
#the convolver automatically returns a 3 octave transform#
```

```
BEGIN
```

```
FN CH_PORT = (([4]t_scratch,t_col),t_col)
```

```
->
```

```
t_memport:REFORM.
```

```
MAKE CONV_ROW:conv_row,
CONV_COL:conv_col.
```

```
LET
```



```

row_reset = CASE direction
  OF forward:conv_reset,
    inverse:PDF1(t_reset,1)(ck,no_rst,conv_reset,rst)  #pipeline delays in col_conv#
  ESAC,
col_reset = CASE direction
  OF forward:PDF1(t_reset,3)(ck,no_rst,conv_reset,rst),
    inverse:conv_reset  #pipeline delays in row_conv#
  ESAC,

col_flag = DFM(t_count_control)(ck,addr_col_read[2],PDF1(t_count_control,1)(ck,reset,addr_col_read[2],
count_0), CAST{bool}direction),

row_flag = DFM(t_count_control)(ck,PDF1(t_count_control,3)(ck,reset,row_flag,count_0),
row_flag, CAST{bool}direction),

direction_sel =CASE direction  #mux control for the in/out data mux's#
  OF forward:left,
    inverse:right
  ESAC,

col_count = MUX_2((t_col,t_count_control))(
  PDF1((t_col,t_count_control),3)(ck,reset,addr_col_read,(col/0,count_rst)),
  addr_col_read,
  direction_sel),

#pipeline delays for the convolver values and input value#
del_conv_col=DFF_NO_LOAD(t_input)(ck,reset,conv_col[1],input/0),

del_conv_row=DFF_NO_LOAD(t_input)(ck,reset,conv_row,input/0),

del_in = DFF_NO_LOAD(t_input)(ck,reset,in,input/0).

```

- 474 -

```

JOIN

(ck,row_reset,direction,MUX_2(t_input){del_in,del_conv_col,direction_sel}, col_flag) ->conv_row,

(ck,col_reset,direction,MUX_2(t_input){del_conv_row,del_in,direction_sel}, pdel,row_control,col_count) ->conv_col.

OUTPUT (MUX_2(t_input){del_conv_col,del_conv_row,direction_sel},CH_PORT(conv_col[2],col_count[1]),row_control,col_count[2],col_flag)
END.

# 1d col convolver, with control #

FN CONV_COL = (bool:ck,t_reset:reset,t_direction:direction,t_input:in,
[4]t_scratch:pdel,t_count_control:row_flag,
(t_col,t_count_control):col_count)
->
(t_input,{[4]t_scratch,t_col}):

#input is data in and, pdel, out from line-delay memories#
# out is (G,H), and line delay out port. The row counter is started 1 cycle later to allow for#
#pipeline delay between MULTIPLIER and this unit #

BEGIN
# a %2 line by line reselable counter for the state machines, out->one on rst#
#carry active on last element of row#
MAC COUNT_2 = (bool:ck,t_reset:reset,t_count_control:carry)
->
t_count_2:

BEGIN

```

- 475 -

```

    MAKE DFF_NO_LOAD[t_count_2]:countdel.
    LET countout= CASE (countdel,carry)
      OF (one,count_carry):two,
         (two,count_carry):one
      ELSE countdel
      ESAC.
    JOIN (ck,reset,countout,one) ->countdel.
    OUTPUT countdel
    END.

```

```

#the code for the convolver#
MAKE MULT_ADD:mult_add,
  [4]DFF1[t_scratch]:pdel_in,
  [4]DFF1[t_scratch]:pdel_out,
  COUNT_2:count.

```

```

# now the state machines to control the convolver#
#First the and gates#

```

```

LET
  reset_row=DFF1[t_reset](ck,reset),      #starts row counter 1 cycle after frame start#
  #we want the row counter to be 1 cycle behind the col counter for the delay for the#
  #pipelined line delay memory#

```

```

  col_carry =DFF_NO_LOAD[t_count_control](ck,reset,col_count[2],count_rst),

```

```

#these need to be synchronised to keep the row counter aligned with the data stream#
#also the delay on col_count deglitches the col carryout#

```

```

  row_control=row_flag,      #signal for row=0,1,2,3, last row, etc#

```

```
andsel=(CASE direction
OF forward: CASE count
OF one:pass,
two:zero
ESAC,
inverse: CASE count
OF one:zero,
two:pass
ESAC
ESAC,

CASE row_control
OF count_0:zero
ELSE pass
ESAC,

CASE direction
OF forward: CASE row_control
OF count_0:zero
ELSE pass
ESAC,
inverse: pass
ESAC),
#now the add/sub control for the convolver address#
addsel= CASE count
OF one:(add,add,add,sub),
two:(add,sub,add,add)
ESAC,
```

```

#now the mux control#
centermuxsel=
CASE direction
OF forward: CASE count
    OF one:(left,right),
       two:(right,left)
    ESAC,
    inverse:CASE count
    OF one:(right,left),
       two:(left,right)
    ESAC

ESAC,

#the perfect reconstruction output#
#the addmuxsel signal#
muxandsel =
CASE direction
OF forward:(andsel[2],pass,andsel[2]),
   inverse:(pass,andsel[2], CASE row_control
    OF count_1:zero
    ELSE pass
    ESAC)

ESAC,

muxsel= CASE direction
OF forward:(uno,

CASE row_control
OF count_0:dos,
   count_carry:tres
ELSE uno
ESAC,

CASE row_control
OF count_0:tres,

```

- 478 -

```

count_carry:quatro
ELSE dos
ESAC),

```

```

inverse:( CASE row_control
OF count_0:dos,
   count_1:quatro,
   count_carry:dos,
   count_lim1:tres
ELSE dos
ESAC,

```

```

CASE row_control
OF count_0:tres,
   count_carry:dos
ELSE uno
ESAC,

```

```

uno)

```

```

ESAC.

```

```

LET

```

```

#ACTEL#

```

```

wr_addr      =DF1(t_col)(ck,DF1(t_col)(ck,col_count[1])),
               #need 2 delays between wr and rd addr#
rd_addr=col_count[1].
               #address for line delay memory#

```

```

#join the control signals to the mult_add block#
JOIN  (ck,reset_row,col_carry)->count,

```

```

(ck,reset,in,andsel,centermuxsel,muxsel,muxandsel,addsel,direction,pdel_out)  ->mult_add.

```

- 479 -

```

FOR INT k=1..4 JOIN
  (ck,mult_addr[k])->pdcl_in[k],    #delay to catch the write address#
  (ck,pdel[k])    ->pdcl_out[k].    #read delay to match MULT delay#

#ACTEL HACK#
LET gh_select = CASE (direction,DF1[t_count_2](ck,count) )
  OF  (inverse,one)((forward,two):right,
      (inverse,two)((forward,one):left
      ESAC,

gh_out = MUX_2[t_scratch](pdcl_in[4],DF1[t_scratch](ck,pdel_out[1]),gh_select),
shift_const= CASE direction
  OF  inverse: CASE DF1[t_count_control](ck,row_control)
      OF  (count_1 | count_2):shift3
      ELSE shift4
      ESAC,
      forward: shift5
      ESAC.

OUTPUT (ROUND_BITS(gh_out,shift_const),(pdcl_in,wr_addr#rd_addr#))    #LOCAMII#
END.
#the 1d convolver, with control and coeff extend#

FN CONV_ROW =(bool:ck,t_reset:reset,t_direction:direction,t_input:in,t_count_control:col_flag)
->
  t_input:

# out is (G,H). The row counter is started 1 cycle later to allow for#
#pipeline delay between MULTIPLIER and this unit #
#the strings give the col & row lengths for this octave#

```

```

BEGIN
    # a %2 line by line resetable counter for the state machines, out->one on rst#
    MAC COUNT_2 = (boolck,t_reset:reset)
    -> t_count_2:

    BEGIN
        MAKE DFF_NO_LOAD(t_count_2):countdel.
        LET countout= CASE (countdel)
            OF (one):two,
               (two):one
            ESAC.
        JOIN (ck,reset,countout,one) ->countdel.
        OUTPUT countdel
        END.

    #the code for the convolver#
    MAKE MULT_ADD:mult_add,
    [4]DF1(t_scratch):pdcl,
    COUNT_2:count.

    # now the state machines to control the convolver#
    #First the and gates#

    LET

    reset_col=DF1(t_reset)(ck,reset),      #starts row counter 1 cycle after frame start#
                                         #makes up for the pipeline delay in MULT#
    #IIILATENCY DEOENDENTII#
    col_control=col_flag,                  #flag when col_count=0,1,2,col_length,etc#

```



```

andsel=(CASE direction
  OF forward: CASE count
    OF one:pass,
       two:zero
    ESAC,
    inverse: CASE count
    OF one:zero,
       two:pass
    ESAC
  ESAC,

  CASE col_control
  OF count_0:zero
  ELSE pass
  ESAC,

  CASE direction
  OF forward: CASE col_control
    OF count_0:zero
    ELSE pass
    ESAC,
    inverse: pass
  ESAC),
#now the add/sub control for the convolver adders#
addsel= CASE count
  OF one:(add,add,add,sub),
     two: (add,sub,add,add)
  ESAC,

#now the mux control#

```

```

centermuxsel=      CASE direction
OF forward: CASE count
                   OF one:(left,right),
                     two:(right,left)
                   ESAC,
                   inverse: CASE count
                   OF one:(right,left),
                     two:(left,right)
                   ESAC
ESAC,
#the addmuxsel signal#
muxandsel =      CASE direction
OF forward:{andself[2],pass,andself[2]},
  inverse:{pass,andself[2], CASE col_control
                   OF count_1:zero
                     ELSE pass
                     ESAC)
ESAC,
muxsel=      CASE direction
OF forward:{uno,
CASE col_control
OF count_0:dos,
  count_carry:tres
ELSE uno
ESAC,
CASE col_control
OF count_0:tres,
  count_carry:quatro
ELSE dos

```

```

        ESAC),

inverse:( CASE col_control
  OF count_0:dos,
    count_1:quatro,
    count_lmt:tres
  ELSE dos
  ESAC,

CASE col_control
  OF count_0:tres,
    count_carry:dos
  ELSE uno
  ESAC,

  uno)

  ESAC.

#join the control signals to the mult_add block#
JOIN  (ck,reset_col) ->count,
#set up the col counters #
      (ck,reset,in,andsel,centermuxsel,muxsel,muxandsel,addsel,direction,pdel)->mult_add.

FOR INT j=1..4 JOIN
      (ck,mult_add[j]) ->pdel[j].      #pipeline delay for mult-add unit#

#ACTEL HACK#
LET   gh_select=CASE direction
      OF inverse: CASE count
        OF one:left,

```

```

        two: right
        ESAC,
        forward: CASE count
        OF one:right,
        two:left
        ESAC
        ESAC,

        gh_out = MUX_2(l_scratch)(pdel[4],DF1(l_scratch)(ck, pdel[1]),gh_select),

        rb_select= CASE direction
        OF inverse:CASE col_control
        OF (count_2 | count_3):shift3
        ELSE shift4
        ESAC,
        forward: shift5
        ESAC.

        OUTPUT ROUND_BITS(gh_out,rb_select)
        END.

        #some string macros#
        MAC EQ_US = (STRING[INT n]bit: a b)
        ->
        bool: BIOP EQ_US.

        #ACTEL 8 bit comparator macro#
        FN ICMP8 = (STRING[8]bit: a b)
        ->
        bool: EQ_US[8](a,b).

```

- 485 -

```

#.....#
#A set of boolean ,ie gate level counters      #
#.....#

#.....#
#The basic toggle flip-flop plus and gate for a synchronous counter #
#input t is the toggle ,outputs are q and tc (toggle for next counter#
#stage                                           #
#.....#

MAC BASIC_COUNT = (bool:ck ,t_reset:reset,bool: tog)
->
[2]bool:

BEGIN
    MAKE DFF_NO_LOAD[bool]:dlat,
        XOR :xor,
        AND :and.

    JOIN (ck,reset,xor,f)->dlat,
        (dlat,tog) ->and,
        (tog,dlat) ->xor.
    OUTPUT (dlat,and)

END.

#.....#
# The n-bit macro counter generator, en is the enable, the outputs #
#are msb(bit 1).....lsb,carry. This is the same order as ELLA strings are stored#
#.....#

MAC COUNT_SYNC(INT n) = (bool:ck,t_reset: reset,bool: en )

```

```

->                                ((n)bool,bool):

(LET out = BASIC_COUNT(ck,reset,en) .

    OUTPUT    IF n=1
    THEN ((1)out[1],out[2])
    ELSE (LET outn = COUNT_SYNC[n-1](ck,reset,out[2]) .
          OUTPUT (outn[1] CONC out[1],outn[2])
        )
    FI
).

#a mod 2^xsize counter#
MAC MOD2_COUNTER_COL = (bool:ck,t_reset:reset)
->

BEGIN    (t_col):

    MAC S_TO_C = (STRING[xsize]bit:in)
->

    MAKE COUNT_SYNC[xsize]:count,
    BOOL_STRING[xsize]:b_s.

    JOIN (ck,reset,t) ->count,    #count always enabled#
    count[1]->b_s.
    OUTPUT (S_TO_C b_s)[2]
END.

#a mod 2^ysize counter#
MAC MOD2_COUNTER_ROW = (bool:ck,t_reset:reset,bool:en)

```

- 487 -

```

-> (t_row):

BEGIN
  MAC S_TO_R = (STRING[ysize]bit:in)
  -> (flag,t_row):BIOP TRANSFORM_US.

  MAKE COUNT_SYNC[ysize]:count,
    BOOL_STRING[ysize]:b_s.

  JOIN (ck,reset,en) ->count,
    count[1] ->b_s.
  OUTPUT (S_TO_R b_s)[2]
  END.

#the basic mod col_length counter, to be synthesised#
MAC BASE_COUNTER_COL = (bool:ck,t_reset:reset,STRING[xsize]bit:octave_cnt_length)
  -> (t_col,t_count_control):

BEGIN
  MAC C_TO_S = (t_col:in)
  -> (flag,STRING[xsize]bit): BIOP TRANSFORM_US.

  MAC FINAL_COUNT = (t_col:in,STRING[xsize]bit:octave_cnt_length)
  -> t_count_control:

  BEGIN
    LET in_us = (C_TO_S in)[2],
      lsb=in_us[xsize].
    #OUTPUT CASE EQ_US(in_us[1..xsize-1],octave_cnt_length[1..xsize-1]) the msb's are the same#
    #ACTEL#

```

- 488 -

```

OUTPUT CASE ICMP8(in_us[1..xsize-1],octave_cnt_length[1..xsize-1]) #the msb's are the same#
OF t: CASE lsb #so check the lsb#
  OF b'1:count_carry, #count odd, so must be length#
    b'0:count_lm1 #count is even so must be length-1#
  ESAC
  ELSE count_rst
  ESAC
END.

MAKE MOD2_COUNTER_COL:mod2_count,
FINAL_COUNT:final_count.

JOIN (mod2_count,octave_cnt_length) ->final_count,
(ck,CASE reset #system reset or delayed carryout reset#
  OF rst: rst
  ELSECASE DFF_NO_LOAD(t_count_control)(ck,reset,final_count,count_0) #latch to avoid glitches#
  OF count_carry:rst
  ELSE no_rst
  ESAC
  ESAC) ->mod2_count.

OUTPUT (mod2_count,final_count)
END.

FN COL_COUNT_ST = (bool:ck,t_reset:reset,STRING[xsize]bit:octave_cnt_length)
->
  (t_col,t_count_control):
  #count value , and flag for count=0,1,2,col_length-1,col_length#

BEGIN
  MAKE BASE_COUNTER_COL:base_col.

  LET count_control = CASE reset

```



- 489 -

```

OF rst:count_0
  ELSE CASE base_col[1]
    OF
      col/0:count_0,
      col/1:count_1,
      col/2:count_2,
      col/3:count_3
    ELSE base_col[2]
    ESAC
  ESAC.

JOIN (ck, reset, octave_cnt_length) -> base_col.
OUTPUT (base_col[1], count_control)
END.

#the basic mod row_length counter, to be synthesised#
MAC BASE_COUNTER_ROW = (bool:ck, t_reset:reset, bool:en, STRING[ysize]bit:octave_cnt_length, t_count_control:col_carry)
->
  (t_row, t_count_control):

BEGIN

MAC R_TO_S = (t_row: in)
->
  ((lag, STRING[ysize]bit): BIOP TRANSFORM_US.

MAC FINAL_COUNT = (t_row: in, STRING[ysize]bit: octave_cnt_length)
->
  t_count_control:

BEGIN
LET in_us = (R_TO_S in)[2].
  lsb=in_us[ysize].
#OUTPUT CASE EQ_US(in_us[1..ysize-1], octave_cnt_length[1..ysize-1]) the msb's are the same#

```

```

#ACTEL#
  OUTPUT CASE ICMP8(in_us[1..ysize-1],octave_cnt_length[1..ysize-1]) #the msb's are the same#
    OF t: CASE lsb
      #so check the lsb#
      OF b'1: count_carry, #count odd, so must be length#
        b'0: count_lm1 #count is even so must be length-1#
      ESAC
      ELSE count_rst
      ESAC
    END.
  MAKE MOD2_COUNTER_ROW: mod2_count,
  FINAL_COUNT: final_count.

#need to delay the reset at end of count signal till end of final row#
#WAS DFF WITH reset#
  LET count_reset = DF1(t_reset)(ck, CASE(final_count, col_carry) #last row/last col#
    OF (count_carry, count_carry): rst #latch to avoid glitches#
    ELSE no_rst
    ESAC).

JOIN (mod2_count, octave_cnt_length) -> final_count,
  (ck, CASE reset
    OF rst: rst
    ELSE count_reset
    ESAC, en) -> mod2_count.
  OUTPUT (mod2_count, final_count)
  END.

FN ROW_COUNT_CARRY_ST = (bool: ck, t_reset: reset, STRING[size]: bit, octave_cnt_length, t_count_control: col_carry)
  ->
  (t_row, t_count_control):

```

## INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US 95/12050A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 H04N1/41 H04N7/26

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO,A,95 19683 (HOUSTON ADVANCED RESEARCH CENTER) 20 July 1995 cited in the application	1-4, 9-11, 15-17, 22-29, 31-33
A	see the whole document  --- -/--	5-8, 12-14, 18-21,30

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

## \* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search

19 January 1996

Date of mailing of the international search report

08.02.96

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (- 31-70) 340-3016

Authorized officer

Isa, S

## INTERNATIONAL SEARCH REPORT

Inter nal Application No

PCT/US 95/12050

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO,A,91 03902 (AWARE INC) 21 March 1991	1-4, 9-11, 15-17, 21,22,31
A	see page 15, line 24 - page 18, line 15; figures  see abstract ---	5-8, 12-14, 18-20, 23-30, 32,33
A	IEEE TRANSACTIONS ON IMAGE PROCESSING, vol. 1, no. 2, April 1992 NEW YORK US, pages 205-220, XP 000367547 ANTONINI ET AL 'Image coding using wavelet transform' see the whole document ---	1-33
A	IEEE SIGNAL PROCESSING MAGAZINE, vol. 8, no. 4, October 1991 NEW YORK, US, pages 14-38, XP 000259548 RIOUL ET AL 'Wavelets and signal processing' see page 31, left column, paragraph 3 - page 32, left column, last paragraph -----	1-33

# INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/US 95/12050

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A-9519683	20-07-95	AU-B- 1727495	01-08-95
-----			
WO-A-9103902	21-03-91	US-A- 5014134	07-05-91
		AU-B- 637020	13-05-93
		AU-B- 6347890	08-04-91
		EP-A- 0491779	01-07-92
		JP-T- 5500294	21-01-93
-----			

- 491 -

```

BEGIN
    MAKE BASE_COUNTER_ROW:base_row.
    LET count_control = CASE reset
        OF rst:count_0
            ELSE CASE base_row[1]
                OF row/0:count_0,
                    row/1:count_1,
                    row/2:count_2,
                    row/3:count_3
            ELSE base_row[2]
            ESAC
        ESAC.
    JOIN (ck,reset,CASE col_carry
        OF count_carry:1
        ELSE 1
        ESAC,octave_cnt_length,col_carry) ->base_row.
    OUTPUT (base_row[1],count_control)
END.

```

```

#the discrete wavelet transform chip/ multi-octave/2d transform with edge compensation#
#when ext & csl are both low latch the setup params from the nubus(active low), as follows#
#adj[1..4] select function#
# 0000 load max_octaves, luminance/colour, forward/inversebar#
# 0001 load yimage#
# 0010 load ximage#
#jump table values#
# 0011 load ximage+1#
# 0100 load 3ximage+3#
# 0101 load 7ximage+7#

```

- 492 -

```

#      0110  load base u addr#
#      0111  load base v addr#

#adl[21..22]  max_octaves#
#adl[23]luminance/crominancebar active low, 1 is luminance, 0 is colour#
#adl[24]forward/inversebar active low, 1 is forward, 0 is inverse#

#adl[5..24]  data (bit 24 lsb)#

FN ST_OCT = (STRING[2]bit:st)
->          (llag,t_octave): BIOP TRANSFORM_US.

FN OCT_ST = (t_octave:st)
->          (llag,STRING[2]bit):BIOP TRANSFORM_US.

FN DWT = (bool:ck_in,t_reset:reset_in,t_input_in_in,bcol:extwritel_in csl_in, STRING[24]bit:adl,
          t_input:sparc_mem_in,[4]t_scratch:pdel_in)

->          (t_input#out IDWT data#[3]t_load#valid out IDWT data,y,u,v#,
          [3]t_load#valid in DWT data y,u,v#,
          t_sparcport#sparc_data_addr,etc#,
          t_memport#pdel_data_out#):

BEGIN
MAKE CONV_2D:conv_2d,
ADDR_GEN_NOSCRATCH:addr_gen,
#active low clock &enable latches#

```

```

[2]DLE1D:max_octave_st,
DLE1D:channel_factor_st,
DLE1D:dir,
[9]DLE1D:col_length_s,
[9]DLE1D:row_length_s,
[9]DLE1D:x_p_1,
[11]DLE1D:x3_p_1,
[12]DLE1D:x7_p_1,
[19]DLE1D:base_u,
[19]DLE1D:base_v,
#active low 3X8 decoder#
DEC3X8A                                :decode!,
#the octave control#
DFF_INIT[t_octave]: octave ,
DFF_INIT[t_channel]: channel ,
JKFF:row_carry_ff,
#pads#
INBUF[STRING[24]bit]:adl_out,
CLKBUF:ck,
INBUF[bool]:extwritel_csl,
INBUF[t_reset]:reset,
INBUF[t_input]:in_sparc_mem,
INBUF[[4]t_scratch]:pdel,
OBHS[t_input]:out1,
OBHS[[3]t_load]:out2 out3,
OBHS[t_sparcport]:out4,
OBHS[t_memport]:out5.
#must delay the write control to match the data output of conv_2d, ie by conv2d_latency#
LET
#set up the control params#

```



- 494 -

```

max_oct = (ST_OCT_BOOL_STRING[2]max_octave_sl)[2],
channel_factor= CAST(t_channel_factor)channel_factor_sl,
col_length = BOOL_STRING[9] col_length_sl,
row_length = BOOL_STRING[9] row_length_sl,

direction =CASE dir
OF  f:forward,
    t:inverse
    ESAC,

#set up the octave params#
convcol_row= conv_2d[3],
convcol_col=conv_2d[4],
convrow_col=conv_2d[5],
#signals that conv_col, for forward, or conv_row, for inverse, has finished that octave#
#and selects the next octave value and the sub-image sizes#

octave_finished =CASE direction
OF  forward:CASE (row_carry_sl,convcol_row,convcol_col)
    OF  (l,count_2,count_2).write #row then col, gives write latency#
    ELSE read
    ESAC,
    inverse:CASE (row_carry_sl,convcol_row,convrow_col)
    OF  (l,count_2,count_3).write #extra row as col then row#
    ELSE read
    ESAC

    ESAC,
#max octaves for ulv#

```

- 495 -

```

max_oct_1 = CASE max_oct
  OF oct/1:oct/0,
     oct/2:oct/1,
     oct/3:oct/2
  ESAC,

y_done = CASE (channel,(OCT_ST octave)[2] EQ_US CASE direction
  OF forward:CAST(STRING [2]bit)max_octave_st,
     inverse:b"00"
  ESAC)

  OF (y,1):1
  ELSE f
  ESAC,

uv_done = CASE (channel,(OCT_ST octave)[2] EQ_US CASE direction
  OF forward:(OCT_ST max_oct_1)[2],
     inverse:b"00"
  ESAC)

  OF (uv,1):1
  ELSE f
  ESAC,

next= (SEQ
  VAR new_oct:=octave,
      new_channel:=channel;
  CASE direction
  OF forward:(CASE octave
      OF oct/0:new_oct:=oct/1,
         oct/1:new_oct:=oct/2,
         oct/2:new_oct:=oct/3

```

```

ESAC;

CASE (y_done,uv_done)
OF  (t,bool)[(bool,t):new_oct:=oct/0
ELSE
ESAC
),

inverse:(CASE octave
OF  oct/3:new_oct:=oct/2,
    oct/2:new_oct:=oct/1,
    oct/1:new_oct:=oct/0
ESAC;
CASE channel
OF  y: CASE octave
    OF  oct/0: CASE channel_factor #watch for colour#
        OF  luminance:new_oct:=max_oct
        ELSE
            new_oct:=max_oct_1
        ESAC
    ELSE
    ESAC,
    u: CASE octave
    OF  oct/0:new_oct:=max_oct_1
    ELSE
    ESAC,
    v: CASE octave
    OF  oct/0:new_oct:=max_oct    #move to y#
    ELSE
    ESAC
ESAC)

```

```

ESAC;
CASE channel_factor
OF luminance:new_channel:=y,
   color: (CASE (channel,y_done)
OF (y,t):new_channel:=u
ELSE
ESAC;
CASE (channel,uv_done)
OF (u,t):new_channel:=v,
   (v,t):new_channel:=y
ELSE
ESAC)
ELSE
ESAC;
OUTPUT (new_oct,new_channel)
),

octave_sel = CASE (octave,channel) #the block size divides by 2 every octave#
OF (oct/0,y):uno, #the uv image starts 1/4 size#
   (oct/1,y):(oct/0,uv):dos,
   (oct/2,y):(oct/1,uv):tres,
   (oct/3,y):(oct/2,uv):quatro
ESAC,
octave_row_length = MUX_4[STRING [ysize]bit](row_length,b"0" CONC row_length[1..ysize-1],
   b"00" CONC row_length[1..ysize-2],
   b"000" CONC row_length[1..ysize-3],octave_sel),
octave_col_length = MUX_4[STRING [xsize]bit](col_length,b"0" CONC col_length[1..xsize-1],
   b"00" CONC col_length[1..xsize-2],
   b"000" CONC col_length[1..xsize-3],octave_sel),

```

```

#load next octave, either on system reset, or write finished#
load_octave= CASE reset
               OF rst:write
               ELSE octave_finished
               ESAC,

#reset the convolvers at the end of an octave, ready for the next octave#
#latch pulse to clean it, note 2 reset pulses at frame start#
#cant glitch as reset&octave_finished dont change at similar times#
conv_reset = CASE reset
               OF rst:rst
               ELSE CASE DFF_NO_LOAD(!_load){ck,reset, octave_finished,read)
               OF write:rst
               ELSE no_rst
               ESAC
               ESAC,

#latch control data off nubus, latch control is active low#
gl = CASE (extwritel,cs1)
      OF (!,0):1
      ELSE 1
      ESAC,

sparc_w=addr_gen[1][2][1], #write addresses#
input_mux=addr_gen[1][1], #input_mux#
sparc_r=addr_gen[1][2][2], #read addresses#
sparc_nw = addr_gen[1][2][3],

```

```

inverse_out = CASE (direction,octave)
OF (inverse,oct/0):CASE (channel,addr_gen[2])
OF (y,write):(write,read,read),
(u,write):(read,write,read),
(v,write):(read,read,write)
ELSE (read,read,read)
ESAC,
(forward,oct/0):(read,read,read)
ELSE (read,read,read)
ESAC,
forward_in = CASE direction
OF forward:CASE (channel,octave,addr_gen[3])
OF (y,oct/0,read):(read,write,write),
(u,oct/0,read):(write,read,write),
(v,oct/0,read):(write,write,read)
ELSE (write,write,write)
ESAC,
inverse:(write,write,write)
ESAC.

JOIN
#in pads#
ck_in ->ck,
reset_in->reset,
extwritel_in ->extwritel,
csl_in ->csl,
adl ->adl_out,
in_in ->in,
sparc_mem_in ->sparc_mem,
pdel_in ->pdel,
#out pads#

```

```

conv_2d[1]    ->out1,
inverse_out   ->out2,
forward_in    ->out3,
addr_gen[1][2] ->out4,
conv_2d[2] ->out5,

#the control section#
(CAST[bool]adl[4],CAST[bool]adl[3],CAST[bool]adl[2]) ->decode1, #active low outs#

(g1,decode1[1],BIT_BOOLadl_out[21]) ->max_octave_sl[1],
(g1,decode1[1],BIT_BOOLadl_out[22]) ->max_octave_sl[2],

(g1,decode1[1],BIT_BOOLadl_out[23]) ->channel_factor_sl,
(g1,decode1[1],BIT_BOOLadl_out[24]) ->dir.

FOR INT j=1..9 JOIN
  (g1,decode[2],BIT_BOOLadl_out[15+j]) ->col_length_sl[j],
  (g1,decode[3],BIT_BOOLadl_out[15+j]) ->row_length_sl[j],
  (g1,decode[4],BIT_BOOLadl_out[15+j]) ->x_p_1[j].

FOR INT j=1..11 JOIN
  (g1,decode[5],BIT_BOOLadl_out[13+j]) ->x3_p_1[j].

FOR INT j=1..12 JOIN
  (g1,decode[6],BIT_BOOLadl_out[12+j]) ->x7_p_1[j].

FOR INT j=1..19 JOIN
  (g1,decode[7],BIT_BOOLadl_out[5+j]) ->base_u[j],
  (g1,decode[8],BIT_BOOLadl_out[5+j]) ->base_v[j].

#sets a flag when row counter moves onto next frame#
JOIN
  (ck,conv_reset,CASE convcol_row
    OF count_carry:1
    ELSE 1

```

```

ESAC,t)                                ->row_carry_ff,

#load the new octave,after the current octave has finished writing#
# on initial reset must load with starting octave value which depends on direction and channel#
(ck,no_rst,load_octave,CASE reset
  OF no_rst:next{1}
  ELSE CASE (direction,channel) #initial octave#
    OF (forward,t_channel):oct/0,
      (inverse,y):max_oct,
      (inverse,u|v):max_oct_1
    ESAC
    ESAC;oct/0)                        ->octave, #next octave#
(ck,no_rst,load_octave,CASE reset
  OF no_rst:next{2}
  ELSE y
  ESAC,y)                            ->channel, #next channel#

(ck,reset,MUX_2{t_input})(in,sparc_mem,CASE input_mux #input_mux#
  OF dwt_in:left,
    sparc_in:right
  ESAC)
,direction,pdel,conv_reset,addr_gen[4],addr_gen[5]) ->conv_2d,

(ck,reset,direction,channel,BOOL_STRING(9)x_p_1,BOOL_STRING(11)x3_p_1,BOOL_STRING(12)x7_p_1,octave_row_length,
octave_col_length,conv_reset,octave_y_done,uv_done,octave_finished,BOOL_STRING(19)base_u,BOOL_STRING(19)base_v) ->addr_gen.

OUTPUT      (out1 ,out2,out3,out4,out5)
END.
FN DWT_TEST = (bool:ck_in,t_reset:reset_in, t_input:in_in,bool:extwrite!_in csl_in,t_sparc_addr:reg_sel value)

```



- 502 -

```

->
                                (t_input[3]t_load[3]t_load):
BEGIN
    FN SPARC_MEM = (t_input.in,t_sparc_addr:rw_addr,t_sparc_addr:rd_addr,t_load:rw_sparc#,t_cs:cs#)
->
    t_input:
    RAM(input/0).

    MAKE DWT:dwt,
        SPARC_MEM:sparc_mem,
        LINE_DELAY(t_scratch):line_delay.

    LET  data_out=dwt[1],
        sparc_port=dwt[4],
        line_delay_port = dwt[5].

    JOIN
        (ck_in,reset_in,in_in,extwrite!_in, csl_in,(SPA_S reg_sel)[2][16..19]CONC b'1* CONC(NOT_B (SPA_S value)[2]), sparc_mem,line_delay)
        ->dwt,
        (data_out,sparc_port[1],sparc_port[2],sparc_port[3]#,sparc_port[4]#)    ->sparc_mem,
        (line_delay_port[1],line_delay_port[2],line_delay_port[3],write)    ->line_delay.

    OUTPUT  dwt[1..3]
    END.

    # some basic macros for the convolver, assume these will#
    #be synthesised into leaf cells#
    #the actel MX4 mux cell#
    FN NOT = (bool:in)
->
    bool:CASE in OF t:1,t ESAC.

```

MAC MX\_4(TYPE ty)=(ty.in1 in2 in3 in4, [2]bool:sel)

->

ty:

CASE sel  
OF (t.f).in1,  
(t.f).in2,  
(t.f).in3,  
(t.f).in4

ESAC.

#the actel GMX4 mux cell#

MAC GMX4(TYPE ty)=(ty.in1 in2 in3 in4, [2]bool:sel)

->

ty:

CASE sel  
OF (t.f).in1,  
(t.f).in2,  
(t.f).in3,  
(t.f).in4

ESAC.

MAC MXT(TYPE ty)=(ty:a b c d, bool:soa sob s1)

->

ty:

CASE s1  
OF t: CASE soa  
OF t:b  
ELSE a  
ESAC,  
t: CASE sob

```

OF t:d
ELSE c
ESAC
ESAC.
MAC ENCODE4_2 = (t_mux4.in)
->
[2]bool:
CASE in
OF uno:(t,f),
dos:(t,t),
tres:(t,f),
quatro:(t,t)
ESAC.

MAC ENCODE3_2 = (t_mux3.in)
->
[2]bool:
CASE in
OF l:(t,f),
c:(t,t),
r:(t,f)
ESAC.

FN DEC3X8A = (bool:a b c)
->
[8]bool:
CASE (a,b,c)
OF (t,t,t):(t,t,t,t,t,t,t,t),
(t,t,t):(t,t,t,t,t,t,t,t),
(t,t,t):(t,t,t,t,t,t,t,t),
(t,t,t):(t,t,t,t,t,t,t,t),

```

```
(t,t):(t,t,t,t,t,t),
(t,t):(t,t,t,t,t,t),
(t,t):(t,t,t,t,t,t),
(t,t):(t,t,t,t,t,t)
ESAC.

MAC_MUX_2[TYPE t]=(t:in1 in2, t_mux:sel)
->
t:
CASE sel
OF left:in1,
right:in2
ESAC.

MAC_MUX_3[TYPE t]=(t:in1 in2 in3, t_mux3:sel)
->
t:
MX_4(t)(in1,in2,in3,in1,ENCODE3_2 sel).

COM
MAC_MUX_4[TYPE t]=(t:in1 in2 in3 in4, t_mux4:sel)
->
t:
CASE sel
OF uno:in1,
dos:in2,
tres:in3,
quatro:in4
ESAC.
MOC
```

```
MAC_MUX_4(TYPE t)=(t:in1 in2 in3 in4, t_mux4:sel)
```

```
->
```

```
t:
```

```
MX_4(t)(in1,in2,in3,in4,ENCODE4_2 sel).
```

```
FN AND2 = (bool:a b)
```

```
->
```

```
bool:BIOP AND.
```

```
MAC GNAND2 = (bool:a b)
```

```
->
```

```
bool:NOT AND2(a,b).
```

```
MAC AND_2 = (t_scratch:in, t_and:sel)
```

```
->
```

```
t_scratch:
```

```
BEGIN
```

```
LET in_s = (t_TO_S(scratch_exp)in)[2].
```

```
sel_s = CAST{bool}sel.
```

```
OUTPUT (S_TO_1(scratch_exp)BOOL_STRING(scratch_exp) ((INT j=1..scratch_exp)AND2(BIT_BOOL in_s[j],sel_s)))[2]
```

```
END.
```

```
FN XOR = (bool: a b)
```

```
->
```

```
bool:
```

```
CASE (a,b)
```

```
OF (t,t):(t,t):t
```

```
ELSE t
```

```
ESAC.
```

```
MAC XOR_B(INT n) = (STRING[n]bit:a b)
->
STRING[n]bit: BIOP XOR.

MAC NOT_B = (STRING[INT n]bit:a)
->
STRING[n]bit:BIOP NOT.

MAC XNOR_B = (STRING[INT n]bit:a b)
->
STRING[n]bit:
NOT_B XOR_B[n](a,b).

FN AND = (bool: a b)
->
bool:
CASE (a,b)
OF (t,t):t
ELSE f
ESAC.

MAC DEL(TYPE t) = (t)
->
t:DELAY(?t,1).

#a general dff same as DFF_NO_LOAD#
MAC DFF (TYPE t)=(bool:ck,t_reset:reset,t,in init_value)
->
t:
BEGIN
```

```
MAKE DEL(t):del.  
JOIN in->del.  
OUTPUT CASE reset  
  OF rst:init_value  
    ELSE del  
      ESAC  
END.
```

```
#a general dff#  
MAC DF1 (TYPE t)=(bool:ck,t:in)  
->  
t:  
  BEGIN  
    MAKE DEL(t):del.  
    JOIN in->del.  
    OUTPUT del  
  END.
```

```
#a general latch#  
MAC DL1 (TYPE ty)=(bool:ck,ty:in)  
->  
ty:  
  BEGIN  
    MAKE DEL(ty):del.  
    JOIN CASE ck  
      OF t:in  
        ELSE del  
      ESAC ->del.  
    OUTPUT CASE ck  
      OF t:in
```

```

ELSE del
ESAC

```

```

END.

```

```

#a general d latch#

```

```

MAC LATCH (TYPE t)={bool:ck,t_load:load,t:in)

```

```

->

```

```

t:

```

```

BEGIN

```

```

MAKE DEL(t):del.

```

```

LET out=CASE load

```

```

OF write:in

```

```

ELSE del

```

```

ESAC.

```

```

JOIN out->del.

```

```

OUTPUT out

```

```

END.

```

```

#an ACTEL D LATCH#

```

```

MAC DLE1D = (bool:ckl loadl,bool:in)

```

```

->

```

```

bool:#qn#

```

```

NOT LATCH(bool)(NOT ckl, CASE loadl

```

```

OF f:write

```

```

ELSE read

```

```

ESAC, ln).

```

```

MAC PDF1(TYPE t,INT n) = (bool:ck,t_reset:reset,t:in initial_value)

```

```

->

```

```

t:

```

```

IF n=0 THEN DFF(t)(ck,reset,ln,initial_value)

```



- 510 -

```

ELSE PDF1(i,n-1)(ck,reset,DFF(i)(ck,reset,in,initial_value),initial_value)
FI.

#a muxed input dff#
MAC DFM (TYPE ty)=(bool:ck,ty:a b,bool:s)
->
ty:
BEGIN
MAKE DEL(iy):del.
JOIN CASE s
  OF f:a,
     t:b
  ESAC ->del.
OUTPUT del
END.

#a resetable DFF, init value is input parameter#
MAC DFF_INIT(TYPE t)=(bool:ck,t_reset:reset,t_load:load,t_in init_value)
->
t:
BEGIN
MAKE DEL(i):del.
LET out=CASE (load,reset)
  OF (write,t_reset):in,
     (read,rst):init_value
  ELSE del
  ESAC.
JOIN out->del.
OUTPUT CASE reset
  OF rst:init_value
  ELSE del

```

- 511 -

```

ESAC
END.

```

```

#a resetable JKFF, k input is active low#
FN JKFF=(bool:ck,t_reset:reset,bool:j k)
->

```

```

bool:
BEGIN
MAKE DEL(bool):del.
LET out=CASE (j,k,reset)
  OF (t,t,no_reset):t,
     (t,t,reset):t,
     (t,t,reset):t,
     (t,t,no_reset):t,
     (t,t,no_reset):del,
     (t,t,no_reset):NOT del
  ESAC.

```

```

JOIN out->del.
OUTPUT CASE reset
  OF rst:f
     ELSE del
  ESAC
END.

```

```

#a diff resetable non-loadable dff#
MAC DFF_NO_LOAD(TYPE t)=(bool:ck,t_reset:reset,t:in init_value)
->

```

```

t:
BEGIN
MAKE DEL(t):del.
JOIN in->del.

```

- 512 -

```

OUTPUT CASE reset
  OF rst_init_value
  ELSE del
  ESAC
END.

MAC PDEL(TYPE t,INT n) = (t:in)
->
t:
  IF n=0 THEN DEL(t)in
  ELSE PDEL(t,n-1) DEL(t) in
  FI.

#the mem control unit for the DWT chip, outputs the memport values for the sparac, and dwt#
#inputs datain from these 2 ports and mux's it to the 2d convolver.#

MAC MEM_CONTROL_NOSCRATCH = (bool:ck,t_reset:reset,t_direction:direction,t_channel:channel,t_octave:octave,
t_sparac_addr:sparac_addr,w_sparac_addr_r,t_load:zero_hh)

->
(t_input_mux,t_sparacport,t_dwtport#dwt#):

BEGIN
#the comb. logic for the control of the i/o ports of the chip#
LET ports = (SEQ
  VAR #defaults, so ? doesnt kill previous mem value#
  nw_sparac:=read,
  nw_dwt:=read,
  cs_dwt:=no_select,
  input_mux:=sparac_in;

```

- 513 -

```

CASE (direction,octave)
OF
  (forward,oct/0): ( cs_dwt:=select;
                    input_mux:=dwt_in),
  (inverse,oct/0):( CASE zero_hh
                    OF  write:(rw_dwt:=write;
                                cs_dwt:=select)
                    ELSE
                      ESAC)

ESAC;

#rw_sparc=write when ck=1 and zero_hh=write, otherwise = read#
rw_sparc:= CAST(t_load)GNAND2(NOT CAST[bool]zero_hh,ck);

#mux the sparc addr on clock#
sparc_addr = GMX4[t_sparc_addr]{sparc_r,sparc_r,sparc_w,sparc_w,ck,f}.#

OUTPUT (input_mux, (sparc_addr_w,sparc_addr_r,rw_sparc), #sparc port#
        (rw_dwt,cs_dwt)
        #dwt port#
        )
).
OUTPUT ports
END.

# the basic 1d convolver without the control unit#

MAC MULT_ADD = (bool:ck,t_reset: reset,t_input:in, [3]t_and:andsel, [2]t_mux:centermuxsel,[3]t_mux4:muxsel,
                [3]t_and:muxandsel,[4]t_add:addsel, t_direction:direction,[4]t_scratch:pdel)

->
[4]t_scratch: #pdel are the outputs from the line delays#

```

```

BEGIN
    MAKE MULTIPLIER:mult,
    [4]ADD_SUB: add.
    #the multiplier outputs#
    LET x3=mult[1],
        x5=mult[2],
        x11=mult[3],
        x19=mult[4],
        x2=mult[5],
        x8=mult[6],
        x30=mult[7],

    #the mux outputs#
        mux1=MUX_4(t_scratch)(x11,x5,x8,x2,muxsel[1]),
        mux2=MUX_4(t_scratch)(x19,x30,x8,scratch/0,muxsel[2]),
        mux3=MUX_4(t_scratch)(x11,x5,x8,x2,muxsel[3]),

        centermux=(MUX_2(t_scratch)(pdel[1],pdel[3],centermuxsel[1]),
            MUX_2(t_scratch)(pdel[2],pdel[4],centermuxsel[2]) ),

    # the AND gates zero the adder inputs every 2nd row#
    #the and gate outputs#
        and1=AND_2(pdel[2],andsel[1]),
        and2=AND_2(pdel[3],andsel[1]),
        and3=AND_2(centermux[1],andsel[2]),
        and4=AND_2(centermux[2],andsel[3]),

        add1in=AND_2(mux1,muxandsel[1]),

```

```

add3in=AND_2(mux3,muxandse[2]),
add4in=AND_2(x3,muxandse[3]).

```

```

JOIN in ->mult,
      (and1,add1in,addse[1]) ->add[1],
      (and3,mux2,addse[2]) ->add[2],
      (and4,add3in,addse[3]) ->add[3],
      (and2,add4in,addse[4]) ->add[4].

```

```

OUTPUT add

```

```

END.

```

```

# the basic multiplier unit of the convolver #

```

```

MAC MULTIPLIER_ST = (t_input:in)

```

```

->

```

```

      [7]t_scratch:
      #x3,x5,x11,x19,x2,x8,x30#

```

```

BEGIN

```

```

      MAC INPUT_TO_S(INT n) = (t_input: in)

```

```

->

```

```

      (flag,STRING[n]bit): BIOP TRANSFORM_S.

```

```

#the multiplier outputs, fast adder code commented out#

```

```

      LET in_s= (INPUT_TO_S(input_exp)in)[2],
      x2=in_s CONC b'0',
      x8=in_s CONC b'000',
      x3 = ADD_S_ACTEL(in_s, x2,b'1),
      x5 = ADD_S_ACTEL(in_s,in_s CONC b'00',b'1 ),
      x11 = ADD_S_ACTEL(x3,x8,b'1),
      x19 = ADD_S_ACTEL(x3,in_s CONC b'0000',b'1),

```

```

x30=ADD_S_ACTEL(x11,x19,b't').

LET subsignal = (x2,x8,x3,x5,x11,x19,x30).
OUTPUT ((S_TO_[input_exp+2] x3)[2],(S_TO_[input_exp+3] x5)[2],(S_TO_[input_exp+4] x11)[2],
        (S_TO_[input_exp+5] x19)[2],(S_TO_[input_exp+1] x2)[2],(S_TO_[input_exp+3] x8)[2],
        (S_TO_[input_exp+6] x30)[2])
END.
MAC INBUF[TYPE t] = (t:pad)
->
t:#y#pad.

MAC OBHS[TYPE t] = (t:d)
->
t:#pad#d.

FN CLKBUF = (bool:pad)
->
bool:pad.
#MAC SHIFT(INT p) = (STRING[scratch_exp]bit) -> STRING[scratch_exp+p]bit:BIOP SR_S[p].#

MAC ADD_S = (STRING[INT m]bit,STRING[INT n]bit)
->
STRING[IF m>=n THEN m+1 ELSE n+1 F]bit:
BIOP PLUS_S.

MAC INV[INT m] = (STRING[m]bit:a)
->
STRING[m]bit:BIOP NOT.

MAC NEG_S = (STRING[INT n]bit)
->

```

```

STRING[n+1]bit:
BIOP NEGATE_S.

MAC ADD_US = (STRING[INT m]bit,STRING[INT n]bit)
->
STRING[IF m>=n THEN m+1 ELSE n+1 F]bit:
BIOP PLUS_US.

MAC CARRY= (L_add:in)
->
STRING[1]bit: CASE in
                                OF add:b'0',
                                sub:b'1'
                                ESAC.

#actel adder macros#

#an emulation of a fast ACTEL 16 bit adder with active low carries#
FN FADD16 = (STRING[scratch_exp]bit: a,b,STRING[1]bit:cinb)
->
  (STRING[scratch_exp]bit,STRING[1]bit):
BEGIN
  LET  a_c=a CONC INV(1)cinb,
        b_c=b CONC INV(1)cinb,
        out=ADD_S(a_c,b_c).
  OUTPUT(out[2..scratch_exp+1],INV(1)B_TO_Sout[1])
END.

#actel 1 bit full adder with active low cin and cout#
MAC FA1B = (bit: ain bin cinb)
->

```



- 518 -

```

(bit,bit):#cob,s#
BEGIN
  LET a_c=B_TO_S ain CONC INV{1}B_TO_S cinb,
      b_c=B_TO_S bin CONC INV{1}B_TO_S cinb,
      out=ADD_US(a_c,b_c).
  OUTPUT(CAST(bit) INV{1} B_TO_S out{1}, out{2})
END.

#the actel version of the ADD BIOP's#

MAC ADD_US_ACTEL = (STRING(INT m)bit:ain,STRING(INT n)bit:bin,bit:cinb)
->
  BEGIN
    MAKE [(IF m>=n THEN m ELSE n FII)FA1B:sum.
          STRING[(IF m>=n THEN m+1 ELSE n+1 FII)bit:
#unsigned nos so extend by 0#
    LET a_c = IF m>=n THEN ain ELSE ZERO(n-m)b"0" CONC ain FI,
        b_c = IF n>=m THEN bin ELSE ZERO(m-n)b"0" CONC bin FI.
    LET subsignal = sum.

#lsb#
  JOIN (a_c[(IF m>=n THEN m ELSE n FII)b_c[(IF m>=n THEN m ELSE n FII)cinb) ->sum[(IF m>=n THEN m ELSE n FII).
  FOR INT j=1..(IF m>=n THEN m ELSE n FI) -1
  JOIN (a_c[(IF m>=n THEN m ELSE n FI) -j],b_c[(IF m>=n THEN m ELSE n FI) -j], sum[(IF m>=n THEN m ELSE n FI) -j+1][(1)]
  >sum[(IF m>=n THEN m ELSE n FI) -j].
  OUTPUT CAST[STRING[(IF m>=n THEN m+1 ELSE n+1 FII)bit]
  (INV{1} B_TO_S sum{1}[1]) CONC

```

```

        CAST{STRING{IF m>=n THEN m ELSE n F}|bit} [INT j=1..IF m>=n THEN m ELSE n F]| sum[j][2])
    END.

MAC ADD_S_ACTEL = (STRING[INT m]bit:ain,STRING[INT n]bit:bin,bit:cinb)
    ->
    BEGIN
        STRING{IF m>=n THEN m+1 ELSE n+1 F}|bit:
        MAKE {IF m>=n THEN m ELSE n F}|FA1B:sum.

        #signed nos so sign extend #
        LET a_c = IF m>=n THEN ain ELSE ALL_SAME{m-n}B_TO_S ain[1] CONC ain F|,
            b_c = IF n>=m THEN bin ELSE ALL_SAME{m-n}B_TO_S bin[1] CONC bin F|.
        LET subsignal = sum.

        #lsb#
        JOIN (a_c{IF m>=n THEN m ELSE n F}|,b_c{IF m>=n THEN m ELSE n F}|,cinb) ->sum{IF m>=n THEN m ELSE n F}|.

        FOR INT j=1..(IF m>=n THEN m ELSE n F) -1
        JOIN (a_c{IF m>=n THEN m ELSE n F}| -j|,b_c{IF m>=n THEN m ELSE n F}| -j|, sum{IF m>=n THEN m ELSE n F}| -j+1[1])
            m>=n THEN m ELSE n F}| -j|. ->sum{IF m>=n THEN m ELSE n F}| -j|.

        OUTPUT CAST{STRING{IF m>=n THEN m+1 ELSE n+1 F}|bit}
        (INV{1} B_TO_S sum[1][1]) CONC
        CAST{STRING{IF m>=n THEN m ELSE n F}|bit} [INT j=1..IF m>=n THEN m ELSE n F]| sum[j][2])
    END.

FN ROUND_BITS = (t_scratch.in,t_round: select)
    ->
    BEGIN
        t_input:

```

```

#THIS ASSUMES THAT THE INPUT_EXP=10!!!!#
#select chooses a round factor of 3, 4, 5#
#the lsb is the right hand of the string,#
#the index 1 of the string is the left hand end, & is the msb#
#so on add ops bit 1 is the carryout#
LET s1 = (l_TO_S[scratch_exp]in)[2],

msb = B_TO_S s1[1],

selector = CASE select      #case conversion for MUX_3#
OF shift3:l,
  shift4:c,
  shift5:r
ESAC,

#needs to be a 16 bit output for the adder#
shift = MUX_3[STRING[scratch_exp]bit](
  msb CONC msb CONC msb CONC s1[1..scratch_exp-3],
  msb CONC msb CONC msb CONC msb CONC s1[1..(scratch_exp-4)],
  msb CONC msb CONC msb CONC msb CONC msb CONC s1[1..scratch_exp-5],
  selector
),

#the carry to round, 1/2 value is rounded towards 0#
cs = CASE select
OF shift4: CASE msb
  OF b*1": s1[scratch_exp-3],      #neg no.#
  b*0": CASE s1[scratch_exp-3..scratch_exp]
    OF b*1000": b*0      #round down on 1/2 value#
    ELSE s1[scratch_exp-3]
  ESAC

```

```

        ESAC,
shift3: CASE msb
    OF b'1':s1[scratch_exp-2], #neg no.#
    b'0': CASE s1[scratch_exp-2..scratch_exp]
        OF b'100':b'0 #round down on 1/2 value#
        ELSE s1[scratch_exp-2]
        ESAC
    ESAC,

shift5: CASE msb
    OF b'1':s1[scratch_exp-4], #neg no.#
    b'0': CASE s1[scratch_exp-4..scratch_exp]
        OF b'10000':b'0 #round down on 1/2 value#
        ELSE s1[scratch_exp-4]
        ESAC
    ESAC,

sum17 = ADD_US_ACTEL(B_TO_S_cs, shift, b'1),
sum = sum17[2..scratch_exp+1],
    #bit 1 is carry out, gives 16 bit sum#
subsignal=(cs,sum),
#ACTEL HACK#
soa = CASE sum[1]
    OF b'1:t, #saturate to -512#
    b'0:1 #saturate to 512#
    ESAC,

ss1 = CASE selector
    OF 1: CASE sum[4..7] #these are the 5 msb's form the 13 bit word#
        OF (b'1111" | b'0000"): t#value in range#

```

- 522 -

```

ELSE f
ESAC,

c: CASE sum[5..7]#these are the 3 msb's from the 12 bit word left after#
    # taking out the 4 sign extension bits#
    OF (b"111" | b"000"): t    #value in range#
    ELSE f
    ESAC,

r: CASE sum[6..7]#these are the 2 msb's from the 11 bit word#
    OF (b"11" | b"00"): t    #value in range#
    ELSE f
    ESAC

    ESAC,
out= MXT{STRING[scratch_exp-6]it}(b"0111111111",b"1000000000",sum[7..scratch_exp],soa,t,ss1).
    OUTPUT (S_TO_IN out)[2]
END.

MAC LINE_DELAY_ST(TYPE t)=([4]t.in,t.col:wr_address,t.col:rd_address,t.load:rw)
->

RAM([4]t).
[4]t:

FN PR_ADDER_ST = (t_scratch:a b)
->
t_scratch:
(S_TO_I[scratch_exp] ADD_S((I_TO_S[scratch_exp-1]a)[2],(I_TO_S[scratch_exp-1]b)[2])) [2].

FN ADD_SUB_ST = (t_scratch: a b, t_add:sel)
->

```

- 523 -

```

t_scratch:
BEGIN

    LET a_s=(l_TO_S[scratch_exp]a)[2],
        b_s=(l_TO_S[scratch_exp]b)[2],
        sel_bit = CAST[STRING[1]bit]sel,
#ACTEL#
        b_s_inv = XOR_B[scratch_exp](b_s, ALL_SAME[scratch_exp]sel_bit),

#cinb is active low so cast sel(add->0,sub->1) & invert it#
        out= ADD_S_ACTEL(a_s,b_s_inv,CAST[bit]INV[1]sel_bit ),
        binout= out[2..scratch_exp+1].
    OUTPUT (S_TO_l[scratch_exp]binout)[2]
END.

MAC ALL_SAME(INT n) = (STRING[1]bit:dummy)
->
STRING[n]bit:
BEGIN
    FAULT IF n < 1 THEN 'N<1 in ALL_SAME' FI.
    OUTPUT IF n=1 THEN dummy
    ELSE dummy CONC ALL_SAME[n-1] dummy
    FI
END.

MAC CAST {TYPE to} = (TYPE from:in)
->
    to:ALIEN CAST.

```

```

MAC ZERO(INT n) = (STRING[1]bit:dummy)
->
STRING[n]bit:
BEGIN
  FAULT IF n < 1 THEN "N<1 in ZERO" FI.
  OUTPUT IF n=1 THEN b"0"
    ELSE b"0" CONC ZERO[n-1] b"0"
    FI
END.

MAC B_TO_S= (bit:in)
->
  STRING[1]bit: CASE in
    OF b"0:b"0" ,
      b"1:b"1"
    ESAC.

MAC I_TO_S(INT n) = (t_scratch: in)
->
  MAC S_TO_I(INT n) = (STRING[n]bit:in)
    (flag,STRING[n]bit): BIOP TRANSFORM_S.
->
  (flag,t_scratch): BIOP TRANSFORM_S.
  MAC S_TO_IN = (STRING[input_exp]bit:in)
->
  (flag,t_input): BIOP TRANSFORM_S.
  MAC IN_TO_S(INT n) = (t_input: in)
->
  (flag,STRING[n]bit): BIOP TRANSFORM_S.
  MAC U_TO_I(INT n) = (STRING[n]bit:in)
->

```

((flag,t\_scratch): BIOP TRANSFORM\_U.

MAC B\_TO\_I= (bit:in)

->

t\_scratch: CASE in

OF b'0:scratch/0,

b'1:scratch/1

ESAC.

MAC CARRY= (t\_add:in)

->

STRING[1]bit: CASE in

OF add:b'0",

sub:b'1"

ESAC.

MAC BOOL\_BIT = (bool:in)

->

STRING[1] bit:

CASE in

OF t:b'1"

ELSE b'0"

ESAC.

MAC BIT\_BOOL= (bit:in)

->

bool:

CASE in

OF b'1:t

ELSE f

ESAC.



```

MAC BOOL_STRING[INT n] = ([n]bool:in)
->
STRING[n] bit:
(LET out = BOOL_BIT in[1].
OUTPUT IF n=1
THEN out
ELSE out[1] CONC BOOL_STRING[n-1](in[2..n])
FI
).

#define a few useful gates #
FN NOT = (bool:in) ->bool:
CASE in
OF t:t,
f:t
ESAC.

FN MUX = (bool:sel in1 in2) -> bool:
# two input mux, select in1 if sel = t, otherwise in2 #
CASE sel
OF t:in2,
f:in1
ESAC.

FN XNOR=(bool:in1 in2)->bool:
CASE (in1,in2)
OF (t,t):t,
(t,t):f,
(t,f):f,
(f,t):f
ESAC.

```

```
FN XOR=(bool:in1 in2) ->bool:
CASE (in1,in2)
OF (t,f):f,
   (f,t):t,
   (t,t):t,
   (f,f):f
ESAC.

FN OR = (bool:in1 in2) ->bool:
CASE (in1,in2)
OF (t, bool)|| (bool,t):t,
   (f,f) : f
ESAC.

#FN MYLATCH = (bool:in) ->bool:DELAY(t,1).#

FN MYLATCH = (t_reset:reset,bool:in) ->bool:
BEGIN
MAKE PDEL[bool,0]:del.
LET out = CASE reset
OF rst:f
ELSE del
ESAC.
JOIN in->del.
OUTPUT out
END.

TYPE t_test = NEW(nolys).
#.....#
#These functions change types from boolean to integer and vice-#
#versa. Supports 1 & 8 bit booleans. #
#.....#
```

```

FN INT_BOOL=(t_input:k)      ->bool:      # 1bit input to binary #
CASE k
OF
  input/0:t,
  input/1:t
ESAC.

FN BOOL_INT=(bool:b) ->t_input:
CASE b
OF
  t:input/0,
  t:input/1
ESAC.

FN * =(t_input:a b)      ->t_input: ARITH a*b.
FN % =(t_input:a b)      ->t_input: ARITH a%b.
FN - =(t_input:a b)      ->t_input: ARITH a-b.
FN + =(t_input:a b)      ->t_input: ARITH a+b.
FN = =(t_input:a b)      ->t_test: ARITH IF a=b THEN 2 ELSE 1 FI.

COM
FN CHANGE_SIGN = (t_input:i) ->t_input:      #changes sign for 8-bit 2's#
ARITH IF i<0 THEN 128+i      #complement no, #
ELSE i
FI.

FN SIGN = (t_input:i) ->bool:      #gets sign for 2's#
ARITH IF i<0 THEN 1      #complement nos #
ELSE 2
FI.

FN TEST_SIZE = (t_input:x)      ->bool:

```

```

#tests to see if the input is bigger than an 8-bit inputeger#
  ARITH IF ( (x<=-128) AND (x>127)) THEN 1
    ELSE 2    FI.

FN INT8_BOOL=(t_input:orig) ->[8]bool:
BEGIN

  SEQ
    VAR i1:=input/0,    #input variables#
    i0:=CHANGE_SIGN(orig),
    b:=(f,f,f,f,f,f,f,SIGN(orig));
    ([INT n=1..7] (
      i1:=i0%input/2;
      b[n]:=INT_BOOL(i0-input/2*i1);
      i0:=i1
    ));
    OUTPUT CASE TEST_SIZE orig    #checks to see if orig will#
    OF t: [8]?bool,    #fit input to an 8_bit value#
    f: b
    ESAC

  END.

FN BOOL_INT8=([8]bool:b) ->t_input:    #converts 8bit boolean to 2's#
BEGIN
  SEQ
    VAR sum:=input/-128 * BOOL_INT(b[8]),
    exp:=input/1;
    ([INT k=1..7]
      (
        sum:=sum+exp*BOOL_INT(b[k]);
        exp:=input/2 * exp
      )
    )
  )

```

```

);
    OUTPUT sum
END.

MOC
FN BOOL_INT10=([10]bool:b)  ->t_input:  #converts 10bit boolean to 2's#
BEGIN
    SEQ
        VAR sum:=input/-512 * BOOL_INT(b[10]),  #complement integer #
            exp:=input/1;
        [INT k=1..9]
            (
                sum:=sum+exp*BOOL_INT(b[k]);
                exp:=input/2 * exp
            );
        OUTPUT sum
    END.
COM
FN BOOL_INT16 =([8]bool:in1 in2)  ->t_input:
# converts a 16-bit no., (lbs,msbs) input to integer form)#
(BOOL_INT8(in1))+((input/256)*BOOL_INT8(in2))+((input/256)*BOOL_INT(in1[8])).
#hack because of sign extend#
#of lsb #
MOC
#compute the mean square difference between two arrays of integers#
FN MSE_COLOUR = (t_reset:reset,t_input:a b)  ->[2]t_int32:
BEGIN
    FN SAVE_ERROR = (t_reset:reset,t_int32:diff32) ->t_int32:
    BEGIN
        MAKE PDEL(t_int32,0):del,

```

```

        PDEL(t_reset,0):edge.

LET   rising = CASE (reset,edge)
      OF   (no_rst,rst):diff32,
            (no_rst,no_rst):del PL diff32
      ELSE del
      ESAC.

JOIN  rising ->del,
      reset ->edge.

OUTPUT del
END.

MAKE SAVE_ERROR:save_error.
LET out =(SEQ
STATE VAR true_count INIT int32/1;
VAR diff:=int32/0,
diff32:=int32/0,
incr:=int32/0;

diff:=CASE reset
OF rst:int32/0
ELSE l_32(a) MI l_32(b)
ESAC;
incr:=CASE reset
OF rst:int32/0
ELSE int32/1
ESAC;
true_count:= CASE reset
OF rst:int32/1
ELSE true_count PL incr
ESAC;

```

```

diff32:= (diff T1 diff);

OUTPUT (diff32,true_count) ).

JOIN      (reset,out[1])      ->save_error.
OUTPUT    (save_error,save_error DV out[2])
END.

#compute the mean square difference between two arrays of integers#

TYPE t_int32 = NEW int32/(-2147483000..2147483000).
INT period_row=9.

FN I_32 = (t_input:in)      ->t_int32:ARITH in.
FN DV = (t_int32:a b)      ->t_int32:ARITH a%b.
FN PL = (t_int32:a b)      ->t_int32:ARITH a+b.
FN MI = (t_int32:a b)      ->t_int32:ARITH a-b.
FN TI = (t_int32:a b)      ->t_int32:ARITH a*b.

FN MSE_ROW = (t_input:a b) ->[3]t_int32:
BEGIN SEQ
    STATE VAR err INIT int32/0,
           count INIT int32/0;
    VAR diff:=int32/0,
        diff32:=int32/0;

    count:=count PL int32/1;

```

```

diff:=CASE count
  OF int32/(1..period_row):int32/0
  ELSE I_32(a) MI I_32(b)
  ESAC;
diff32:= (diff TI diff);
err:=err PL diff32;
OUTPUT (err, err DV count,count)
END.

FN PRBS10 = (t_reset:reset) ->[10]bool:
#A 10 bit prbs generator,feedback taps on regs 3 & 10.#
BEGIN
  MAKE [10]MYLATCH:I,
  XNOR:xnor.

  FOR INT k=1..9 JOIN
    (reset,[k]) ->[k+1].

  JOIN (reset,xnor) ->[1],
    ([10],[3]) ->xnor.

  OUTPUT I
END.

FN PRBS11 = (t_reset:reset) ->[10]bool:
#A 11 bit prbs generator,feedback taps on regs 2 & 11.#
BEGIN
  MAKE [11]MYLATCH:I,
  XNOR:xnor.

```



```

FOR INT k=1..10  JOIN
  (reset,[k])    ->[k+1].

JOIN  (reset,xnor) ->[1],
      ([11],[2])  ->xnor.

OUTPUT  [1..10]

END.
COM
FN PRBS16 = (bool:reset) ->[16]bool:
#A 16 bit prbs generator,feedback taps on regs 1,3,12,16#
BEGIN
  MAKE [16]MYLATCH:l,
  XOR_4:xor,
  NOT:xnor.

FOR INT k=1..15  JOIN
  (ck,reset,[k]) ->[k+1].

JOIN  (ck,reset,xnor) ->[1],
      ([1],[3],[16],[12]) ->xor,
      xor ->xnor.
OUTPUT  ([INT k=1..16][k])

END.
FN PRBS12 = (clock:ck,bool:reset) ->[12]bool:
#A 12 bit prbs generator,feedback taps on regs 1,4,6,12.#
BEGIN
  MAKE [12]MYLATCH:l,
  XOR_4:xor,
  NOT:xnor.

```

```

FOR INT k=1..11 JOIN
  (ck,reset,[k]) ->[k+1].

JOIN  (ck,reset,xnor) ->[1],
      ([1],[4],[6],[12]) ->xor,
xor   ->xnor.
OUTPUT  ((INT k=1..12)[k])

END.

FN PRBS8 = (clock:ck,bool:reset) ->[8]bool:
#A 8 bit prbs generator,feedback taps on regs 2,3,4,8.#
BEGIN
  MAKE [8]MYLATCH:1,
  XOR_4:xor,
  NOT:xnor.

FOR INT k=1..7 JOIN
  (ck,reset,[k]) ->[k+1].

JOIN  (ck,reset,xnor) ->[1],
      ([2],[3],[4],[8]) ->xor,
xor   ->xnor.
OUTPUT  ((INT k=1..8)[k])

END.

MOC
#TEST FOR Y U V #
#to test the 2d convolver using prbs input into the forward convolver#
#then outputting to the Inverse convolver and checking against the original result#

```

```

FN TEST_COLOUR = (bool:ck,t_reset:reset,bool:extwrite!_in csl_in, t_sparc_addr:reg_sel value,t_reset:prbs_reset)
->[3]t_int32:

BEGIN

    FN DEL = (t_load:in)      ->t_load:DELAY(read,1).

    FN PULSE = (t_load:in) ->t_reset:
        CASE (in,DEL in)
            OF   (write,read):rst
            ELSE no_rst
            ESAC.

    MAKE PRBS11:prbs,
    BOOL_INT10:int_bool,
    DWT:dwt,
    [3]MSE_COLOUR:mse_colour.

JOIN    (CASE (prbs_reset,PULSE CASE dwt[3][2]
              OF write:read,
                read:write
              ESAC,PULSE CASE dwt[3][3]
              OF write:read,
                read:write
              ESAC,PULSE dwt[2][1],PULSE dwt[2][2],PULSE dwt[2][3])

          (rst,t_reset,t_reset,t_reset,t_reset,t_reset)((t_reset,rst,t_reset,t_reset,t_reset,t_reset))
          ((t_reset,t_reset,rst,t_reset,t_reset,t_reset))((t_reset,t_reset,t_reset,rst,t_reset,t_reset))
          ((t_reset,t_reset,t_reset,t_reset,t_reset,rst,t_reset,t_reset,t_reset,t_reset,rst,t_reset,rst)
          ELSE no_rst
          ESAC)

          #rerun the prbs at start, or on out of IDWT#
          ->prbs,

```

```

prbs          ->int_bool,
(ck,reset,int_bool,extwritel_in,cs1_in,reg_sel,value)  ->dwt.

#calculate the mse error for each channel#
FOR INT j=1..3 JOIN
(CASE dwl[2][j]
OF read:rst
ELSE no_rst
ESAC,dwl[1],int_bool) ->mse_colour[j].
OUTPUT (mse_colour[1][1],mse_colour[2][1],mse_colour[3][1])
END.

FN DWT = (bool,t_reset,t_input,bool,bool,t_sparc_addr:reg_sel value)  ->(t_input,[3]t_load,[3]t_load):IMPORT.
MAC PDEL(TYPE t, INT n) =() ->t:IMPORT.

IMPORTS      dwt/strng: DWT_TEST( RENAMED DWT) PDEL.

#TEST FOR LUMINANCE ONLY#
#to test the 2d convolver using prbs Input into the forward convolver#
#then outputting to the inverse convolver and checking against the original result#

FN TEST_Y = (bool:ck,t_reset:reset,bool:extwritel_in cs1_in, t_sparc_addr:reg_sel value,t_reset:prbs_reset)
->[2]t_int32:

BEGIN
  FN DEL = (t_load:in)  ->t_load:DELAY(read,1).
  FN PULSE = (t_load:in) ->t_reset:
  CASE (in,DEL in)

```

```

OF      (write,read):rst
ELSE   no_rst
ESAC.

MAKE PRBS11:prbs,
BOOL_INT10:intl_bool,
DWT:dwt,
MSE_COLOUR:mse_colour.

JOIN   (CASE (prbs_reset,PULSE dwt[2][1])  #rerun the prbs at start, or on out of IDWT#
OF      (rst,t_reset))((t_reset,rst):rst
ELSE   no_rst
ESAC)  ->prbs,

prbs   ->intl_bool,
(ck,reset,intl_bool,extwritel_in,csl_in,reg_sel,value)  ->dwt,
(CASE dwt[2][1]
OF read:rst
ELSE no_rst
ESAC,dwt[1],intl_bool)  ->mse_colour.

OUTPUT mse_colour
END.

```

APPENDIX B-2

```

#test for abs #

FN ABS_TEST = (STRING[10]bit:in in2)  ->bool: in LE_U in2.
#the state machine to control the address counters#
#only works for 3 octave decomposition in y/2 in ulv#

FN CONTROL_ENABLE = (bool:ck,t_reset:reset,t_channel:new_channel channel,[3]bool:c_blk,STRING[2]bit:subband,
t_load:load_channel,t_mode:new_mode)

->([3]bool#en_blk#,t_octave,[2]bool#tree_done,lpf_block_done#,t_state#reset_state#):

BEGIN
  MAKE DF1(t_state):state.
  #set up initial state thro mux on reset, on HH stay in zz0 state#
  LET start_state = CASE channel
    OF ulv:down1,
      y:up0
    ESAC,
    reset_state= CASE reset
      OF rst: start_state
      ELSE state
      ESAC.

  LET next_values = (SEQ
    VAR en_blk:=f, #enable blk_count#
    lpf_block_done:=f, #enable x_count for LPF#
    tree_done:=f, #enable x_count for other subbands#
    new_state:=reset_state,
    octave:=?t_octave; #current octave#

  CASE reset_state

```

```

ELSE
  ESAC),
  zz1: ( octave:=oct/0;
        en_blk[1]:=t;
        CASE c_blk[1]
        OF t:(new_state:=zz2;
              en_blk[2]:=t)
        ELSE
          ESAC),
  zz2: ( octave:=oct/0;
        en_blk[1]:=t;
        CASE c_blk[1]
        OF t:(new_state:=zz3;
              en_blk[2]:=t)
        ELSE
          ESAC),
  zz3: ( octave:=oct/0;
        en_blk[1]:=t;
        CASE c_blk[1]
        OF t:(new_state:=down1;
              en_blk[2]:=t; #roll over to 0#
              en_blk[3]:=t  #because state zz3 clock 1 pulse#
              )
        ELSE
          ESAC
        ),
  down1: ( octave:=oct/1;
          en_blk[2]:=t;
          CASE o_blk[2]

```

#now decide the next state, on block{1} carry check the other block carries#



```

OF up0: ( octave:=oct/2;
  en_blk[3]:=t;
  CASE c_blk[3]
  OF t:(CASE subband
    OF b'00*:lpf_block_done:=t  #clock x_count for LPF y channel#
    ELSE new_state:=up1  #change state when count done#
    ESAC;
  CASE new_mode  #in luminance & done with that tree#
  OF stop:tree_done:=t
  ELSE
  ESAC)
  ELSE
  ESAC),
  up1: ( octave:=oct/1;
  en_blk[2]:=t;
  CASE c_blk[2]
  OF t:(new_state:=zz0;
  CASE new_mode  #in luminance, terminate branch & move to next branch#
  OF stop:(new_state:=down1;
    en_blk[3]:=t)
  ELSE
  ESAC)
  ELSE
  ESAC),
  zz0: ( octave:=oct/0;
  en_blk[1]:=t;
  CASE c_blk[1]
  OF t:(new_state:=zz1;
    en_blk[2]:=t)

```

```

OF t:(CASE subband
  OF b"00":lpf_block_done:=t    #clock x_count for LPF u/v channel#
  ELSE new_state:=zz0    #change state when count done#
ESAC;

CASE (new_mode,channel)    #stop so finish this tree/branch & move on#
OF (stop,u/v):tree_done:=t,
  (stop,y):(en_blk[3]:=t;
    CASE c_blk[3]    #move to next tree#
    OF:tree_done:=t
    ELSE new_state:=down1
    ESAC
  )
ELSE
  ESAC)
ELSE
  ESAC)
ELSE
  ESAC)
ELSE
  ESAC)

ESAC;

CASE channel
OF u/v: CASE (c_blk[1],c_blk[2])
  OF (t,t):tree_done:=t
  ELSE
    ESAC,
  y: CASE (c_blk[1],c_blk[2],c_blk[3])
    OF (t,t,t):tree_done:=t
    ELSE
      ESAC

ESAC;

```

```

#now change to start state if the sequence has finished#
CASE tree_done #in LPF state doesn't change when block done#
OF: new_state:= start_state
ELSE
ESAC;

#on channel change, use starting state for new channel#
CASE load_channel #in LPF state doesn't change when block done#
OF write_new_state:= CASE new_channel
    OFy:up0,
        ulv:down1
    ESAC
ELSE
ESAC;

OUTPUT (new_state,en_blk,octave,(tree_done,lpf_block_done))
).

JOIN (ck,next_values[1]) ->state.
OUTPUT (next_values[2],next_values[3],next_values[4],reset_state)
END.

FN CHECK = (t_inputx sub size y,t_octave: oct) -> t_sparc_addr:
    ARITH ((x SL 1)+(1 AND sub) + size*(y SL 1) +(sub SR 1)))SL oct.

#these are the addr gens for the x & y addresses of a pixel given the octave#
#sub&blk no. for each octave. Each x&y address is of the form #
# x= count(5 bits)(blk(3)..blk(octave+1)){s} {octave 0's} #

```

- 545 -

```

# y= count(5 bits){blk(3)..blk(octave+1)}{s} {octave 0's}      #
#this makes up the 9 bit address for CIF images              #
#the blk & s counters are vertical 2 bit with the lsb in the x coord #
#and carry out on 3, last counter is both horiz and vertical counter#
#read_enable enable the block count for the read address, but not the #
#carry-outs for the mode change, this is done on the write addr cycle #
#by write_enable, so same address values generated on read & write cycles#

FN ADDR_GEN = (bool:ck, t_reset:reset, t_channel:new_channel channel, t_load:load_channel STRING[2]bit:sub_count,
               STRING[xsize]bit:col_length, STRING[ysize]bit:row_length, STRING[xsize]bit:ximage_string,
               STRING[ysize]bit:yimage_string, STRING[1]bit:yimage_string_3#yimage*2.5#,
               bool:read_enable write_enable, t_mode:new_mode)

-> (t_sparc_addr, t_octave, bool#sub_finished#, bool#tree_done#, bool#lpf_done#, t_state):
BEGIN
  MAKECOUNTER(xsize-4):x_count,
  COUNTER(ysize-4):y_count,
  CONTROL_ENABLE:control,
  [3]BLK_SUB_COUNT:blk_count.

#size of lpf images/2 -1, for y,lv. /2 because count in pairs of lpf values #
#lpf same size for all channels!!!#

LET (x_lpf, y_lpf) = (col_length[1..xsize-4], row_length[1..ysize-4]),

tree_done = control[3][1],
lpf_block_done = control[3][2],
x_en = CASE (tree_done, lpf_block_done)
  OF (t, bool) [(bool, t)
  ELSE f
  ESAC,

```

```
blk_en=control[1],
octave=control[2],
```

#clk y\_count when all blocks done for subs 1-3, or when final blk done for lpf#

```
y_en = CASE sub_count
      OF b'00': CASE (lpf_block_done, x_count[2])
        OF (1,1):
          ELSE f
        ESAC
      ELSE CASE (tree_done, x_count[2])
        OF (1,1):
          ELSE f
        ESAC
      ESAC,
```

```
x_msb_out = CASE channel
      OF y: x_count[1] CONC B TO S(blk_count[3][1][2]), #always the msb bits#
        ulv: b'0' CONC x_count[1]
      ESAC,
y_msb_out = CASE channel
      OF y: y_count[1] CONC B TO S(blk_count[3][1][1]),
        ulv: b'0' CONC y_count[1]
      ESAC,
```

```
x_lsb_out = CASE (octave) #bit2 is lsb#
      OF (oct0): ((INT k=1..2) blk_count[3-k][1][2]) CONC sub_count[2],
        (oct1): (blk_count[2][1][2], sub_count[2], b'0'),
        (oct2): sub_count[2] CONC [2]b'0
      ESAC,
```

```

y_lsb_out = CASE (octave)      #bit 1 is msb#
  OF (oct0):(INT k=1..2)blk_count[3-k][1][1]CONC sub_count[1],
    (oct/1):(blk_count[2][1][1], sub_count[1], b'0'),
    (oct/2):sub_count[1] CONC [2]b'0
  ESAC,
x_addr = x_msb_out CONC BIT_STRING(3)x_lsb_out,
y_addr = y_msb_out CONC BIT_STRING(3)y_lsb_out,

#enable the sub band counter#
sub_en = CASE (y_count[2],y_en)
  OF (t,i):t
  ELSE f
  ESAC,

lpf_done = CASE sub_count
  OF b'00': sub_en      #!!!!CHANGE ACCORDING TO LATENCY IN DECODE#
  ELSE f
  ESAC,

base_y_sel = CASE channel
  OF y:l,
    u:c,
    v:r
  ESAC,

base_rows = MUX_3(STRING(1)blk)(ZERO(1)1b'0'b'0' CONC yimage_string[1..ysize]CONC b'0',
                  yimage_string_3,base_y_sel),
#base address for no of rows for y,u & v memory areas#

address = x_addr ADD U ((y_addr ADD U base_rows)[2..12]) MULT_U (CASE channel
  OF y:ximage_string,

```

- 548 -

```

        u/v:(SR_U(1)ximage_string)[1..xsize]
        ESAC)
    ),

    int_addr = (S_TO_SPARC_address)[2].

    JOIN  (ck,reset,x_en,x_lpf)    ->x_count,
          (ck,reset,y_en,y_lpf)    ->y_count,
    #use new_channel so on channel change control state picks up correct value#
    (ck,reset,new_channel,channel,((INT|=1..3)blk_count[j][2]),sub_count,load_channel,new_mode)
    ->control.

    FOR INT k=1..3 JOIN  (ck,reset,blk_en[k],read_enable OR write_enable)    ->blk_count[k].

    OUTPUT (int_addr,octave,sub_en,tree_done,lpf_done,control[4])
    {
    END.
    },
    #a counter to control the sequencing of r/w, token, huffman cycles#
    #decide reset is enabled 1 cycle early, and latched to avoid glitches#
    #lpf_stop is a dummy mode to disable the block writes&huffman data#
    #cycles for that block#

    FN CONTROL_COUNTER = (bool:ck,t_reset:reset,t_mode:mode new_mode,t_direction:direction)
    ->(t_load,t_cycle,t_reset,bool:t_load,t_cs,t_load,t_cs):

    #mode load,cycle,decide reset,read_addr_enable,write_addr_enable,load flags#
    #decode write_addr_enable early and latch to avoid feedback loop with pro_mode#
    #in MODE_CONTROL#
    BEGIN
        MAKE COUNT_SYNC(4):count.

```

- 549 -

```

LET count_len = (U_TO_LEN(4) count{1})[2].
LET out = (SEQ
  VAR cycle:=skip_cycle,
    decide_reset:=no_rst,
    load_mode:=read,
    load_flags:=read,
    cs_new:=no_select,
    cs_old:=select,
    rw_old:=read,
    read_addr_enable:=f,
    write_addr_enable:=f;

```

```

CASE direction
OF forward: CASE mode
  OF send|still_send|lpf_send: CASE count_len
    OF len/(0.3):(read_addr_enable:=t;
      cs_new:=select),
      len/(4):(cycle:=token_cycle;
        load_flags:=write;
        write_addr_enable:=t),
      len/(5..7) : (write_addr_enable:=t;
        CASE new_mode
        OF stop|lpf_stop:(cycle:=skip_cycle;
          rw_old:=read;
          cs_old:=no_select),
          vold:(cycle:=skip_cycle;
            rw_old:=write)
        ELSE (cycle:=data_cycle;
          rw_old:=write)

```



```

        ESAC),
len/8:(decide_reset:=rst;
CASE new_mode
    OF stop|pf_stop:(cycle:=skip_cycle;
        rw_old:=read;
        cs_old:=no_select),
        void:(cycle:=skip_cycle;
            load_mode:=write;
            rw_old:=write)
    ELSE (cycle:=data_cycle;
        load_mode:=write;
        rw_old:=write)
        ESAC)
ELSE
ESAC,

still: CASE count_len
    OF len/(0..3):(read_addr_enable:=t;
        cs_new:=select),
        len/(4):(cycle:=token_cycle;
            write_addr_enable:=t;
            load_flags:=write),
        len/(5..7):(rw_old:=write;
            write_addr_enable:=t;
            CASE new_mode
                OF void_still:(cycle:=skip_cycle
                ELSE cycle:=data_cycle
                ESAC),
            len/8:(decide_reset:=rst;

```

- 551 -

```

rw_old:=write;
load_mode:=write;
CASE new_mode
OF void_still:cycle:=skip_cycle
ELSE cycle:=data_cycle
ESAC)

```

```

ELSE
ESAC,

```

```

lpf_still: CASE count_len
OF len/(0..3):(read_addr_enable:=t;
               cs_new:=select),
   len/4:(cycle:=token_cycle;
          write_addr_enable:=t;
          load_flags:=write),
   len/(5..7):(cycle:=data_cycle;
              rw_old:=write;
              write_addr_enable:=t),
   len/8:(cycle:=data_cycle;
          rw_old:=write;
          decide_reset:=rst;
          load_mode:=write)
ELSE
ESAC,

```

```

void: CASE count_len
      OF len/(0..3):(read_addr_enable:=t;
                     cs_new:=select),
      len/4:(load_flags:=write;
             cycle:=token_cycle; #dummy token cycle for mode update#

```

```

write_addr_enable:=t),
  len/5..7:(write_addr_enable:=t; #keep counters going#
CASE new_mode
  OF
    stop:(rw_old:=read;
      cs_old:=no_select)
  ELSE rw_old:=write
    ESAC),
  len/8:(decide_reset:=rst;
CASE new_mode
  OF
    stop:(rw_old:=read;
      cs_old:=no_select)
  ELSE (load_mode:=write;
    rw_old:=write)
    ESAC)

ELSE
  ESAC,

void_still: CASE count len
  OF len/0: write_addr_enable:=t, #allow for delay#
  len/1..3:(write_addr_enable:=t;
    rw_old:=write),
    len/4:(rw_old:=write;
      load_mode:=write;
      decide_reset:=rst)
  ELSE
    ESAC

ELSE
  ESAC,

Inverse: CASE mode

```

```

OF send|still_send|pf_send: CASE count_len
  OF len/(0..3): (read_addr_enable:=t),
    len/(4): (cycle:=token_cycle;
              write_addr_enable:=t;
              load_flags:=write),
    len/(5..7): (write_addr_enable:=t;
                  CASE new_mode
                    OF stop|pf_stop: (cycle:=skip_cycle;
                                         rw_old:=read;
                                         cs_old:=no_select),
                      void: (cycle:=skip_cycle;
                              rw_old:=write)
                    ELSE (cycle:=data_cycle;
                          rw_old:=write)
                      ESAC),
    len/8: (decide_reset:=rst;
            CASE new_mode
              OF stop|pf_stop: (cycle:=skip_cycle;
                               rw_old:=read;
                               cs_old:=no_select),
                void: (cycle:=skip_cycle;
                       load_mode:=write;
                       rw_old:=write)
              ELSE (cycle:=data_cycle;
                    load_mode:=write;
                    rw_old:=write)
              ESAC)
            ELSE
              ESAC,

```

```

still:  CASE count_len
        OF len(0);,      #skip to allow reset in huffman#
        len/(1):(cycle:=token_cycle;
                    write_addr_enable:=1),
        len/(2..4):(rw_old:=write;
                    write_addr_enable:=1;
        CASE new_mode
        OF void_still:cycle:=skip_cycle
        ELSE cycle:=data_cycle
        ESAC),

        len/5:( rw_old:=write;
                decide_reset:=rst;
        load_mode:=write;
        CASE new_mode
        OF void_still:cycle:=skip_cycle
        ELSE cycle:=data_cycle
        ESAC)
        ELSE
        ESAC,
lpf_still: CASE count_len
        OF len(0);,      #match with previous#
        len/(1):(      #skip for write enb delay#
                    write_addr_enable:=1),
        len/(2..4):(cycle:=data_cycle;
                    rw_old:=write;
                    write_addr_enable:=1),
        len/5:(cycle:=data_cycle;
                    rw_old:=write;
                    decide_reset:=rst;
                    load_mode:=write)

```

```

ELSE
ESAC,
CASE count_len
OF len/(0..3):(read_addr_enable:=t),
   len/4:(load_flags:=write;
           write_addr_enable:=t),
   len/(5..7):(write_addr_enable:=t;
CASE new_mode
  OF stop:(rw_old:=read;
            cs_old:=no_select)
   ELSE rw_old:=write
   ESAC),
len/8:(decide_reset:=rst;
CASE new_mode
  OF stop:(rw_old:=read;
            cs_old:=no_select)
   ELSE (load_mode:=write;
         rw_old:=write)
   ESAC)

ELSE
ESAC,
CASE count_len
OF len/(0).., #match with rest#
len/1:write_addr_enable:=t, #dummy as write delayed#
   len/(2..4):(write_addr_enable:=t;
               rw_old:=write),
   len/5: (rw_old:=write;
           load_mode:=write;
           decide_reset:=rst)
   ELSE

```

```

        ELSE
        ESAC
    ESAC;

    OUTPUT (load_mode,cycle,DF1(t_reset){ck,decide_reset},read_addr_enable,
        DFF{bool}{ck,reset,write_addr_enable,t},load_flags,
        cs_new,rw_old,cs_old)
    ).

    JOIN (ck,CASE reset
        OF rst:rst
        ELSE out[3]
        ESAC,t) ->count.

    OUTPUT out
    END.

#.....#
#A set of boolean ,le gate level counters #
#.....#

#.....#
#The basic toggle flip-flop plus and gate for a synchronous counter #
#input t is the toggle ,outputs are q and tc (toggle for next counter#
#stage #
#.....#

MAC BASIC_COUNT = (bool:ck ,t_reset:reset,bool: tog) ->(STRING[1]bit,bool):
```

```

BEGIN
    MAKE DFF{boolf}:dlat,
    XOR :xor,
    AND :and.

    JOIN (ck,reset,xor,f)->dlat,
        (dlat,tog) ->and,
        (tog,dlat) ->xor.
    OUTPUT (CAST{STRING[1]bit} dlat,and)

END.

# .....#
# # The n-bit macro counter generator, en is the enable, the outputs #
# are msb(bit 1).....lsb,carry. This is the same order as ELLA strings are stored#
# .....#

MAC COUNT_SYNC{INT n} = (bool:ck,t_reset: reset,bool: en )->(STRING[n]bit,bool):
(LET out = BASIC_COUNT(ck,reset,en) .

    OUTPUT ( IF n=1
        THEN (out[1],out[2])
        ELSE ( LET outn = COUNT_SYNC{n-1}(ck,reset,out[2]) .
            OUTPUT (outn[1] CONC out[1],outn[2])
        )
        FI)
    ).
COM
FN TEST_COUNT_SYNC = (bool:ck,t_reset: reset,bool: en ) ->([4]bool,bool):
COUNT_SYNC{4}(ck,reset,en).
MOC

```



```

#.....#
#The basic toggle flip-flop plus and gate for a synchronous counter #
#input t is the toggle, updown delms the direction, outputs are q and #
# tc (toggle for next counterstage, active low for down/high for up) #
#.....#

```

```

MAC BASIC_COUNT_UD = (bool:ck,t_reset:reset,bool: tog, t_updown:updown) ->[2]bool:

```

```

BEGIN

```

```

    MAKE DFF{bool}:dlat.

```

```

    LET toggle = tog,

```

```

    xorn = CASE updown

```

```

    OF up: CASE (toggle,dlat) #xor#

```

```

        OF (t,t)/(f,f):f

```

```

        ELSE t

```

```

    ESAC,

```

```

    down: CASE (toggle,dlat) #xnor#

```

```

        OF (t,t)/(f,f):t

```

```

        ELSE f

```

```

    ESAC

```

```

    ESAC,

```

```

    cout = CASE updown

```

```

    OF up: CASE (dlat,toggle) #AND#

```

```

        OF (t,t):t

```

```

        ELSE f

```

```

    ESAC,

```

```

    down: CASE (dlat,toggle) #OR#

```

```

        OF (f,f):f

```

```

        ELSE t

```

```

    ESAC

```

```

ESAC.

JOIN (ck,reset,xorn,f)->dlat.
OUTPUT (dlat,cout)

END.

#.....#
# The n-bit macro u/d counter generator, en is the enable, the outputs #
# are msb(bit 1).....lsb,carry. This is the same order as ELLA strings are stored#
# first enable is active low on down, so invert. #
#.....#
MAC COUNT_SYNC_UD(INT n) = (bool:ck,t_reset: reset,bool:en,t_updown:updown) ->(STRING[n]bit,bool):
BEGIN
    MAKE [n]BASIC_COUNT_UD:basic_count.
    LET enable = ((INT k=1..n-1) basic_count[k+1][2]) CONC CASE updown #invert enable if down count#
    OF up:en
    ELSE NOT en
    ESAC.
    FOR INT k=1..n JOIN (ck,reset,enable[k],updown) ->basic_count[k].
    OUTPUT (BOOL_STRING(n)((INT k=1..n]basic_count[k][1]), basic_count[1][2])
    END.
COM
FN TEST_COUNT_SYNC_UD = (bool:ck,t_reset: reset,bool:en,t_updown:updown) ->([4]bool,bool):
COUNT_SYNC_UD[4](ck,reset,en,updown).
MOC

#the basic x/y counter, carry out 1 cycle before final count given by x_lpf/y_lpf#
MAC COUNTER(INT n) = (bool:ck,t_reset:reset,bool:en,STRING[n]bitx_lpf) ->(STRING[n]bit,bool):
BEGIN

```

```

MAKE COUNT_SYNC(n):x_count.

LET out = x_count[1].
  final_count = out EQ_U x_lpf,
  final_count_en=CASE (final_count,en)
    OF (t):t
    ELSE f
    ESAC,
#reset after 4 counts at final count value#
cnt_reset = CASE reset
  OF rst:rst
  ELSE CASE DF1(bool)(ck,final_count_en) #reset taken out of DFF 12/6#
    OF t:rst
    ELSE no_rst
    ESAC
  ESAC.
JOIN (ck,cnt_reset,en) ->x_count.
OUTPUT (out,final_count)
END.
COM
#the basic y counter, carry out 1 cycle before final count given by y_lpf#
#reset at end of channel given by system reset #
MAC Y_COUNTER = (bool:ck,t_reset:reset,bool:en,STRING[4]bit:y_lpf) ->(STRING[4]bit,bool):
BEGIN

MAKE COUNT_SYNC(4):y_count.

LET out = y_count[1].
JOIN (ck,reset,en) ->y_count.
OUTPUT (out, out EQ_U y_lpf)

```

END.  
MOC

COM

#the blk, or sub-band counters, carry out on 3#

FN BLK\_SUB\_COUNT = (bool:ck,t\_reset:reset, bool:en)      ->(STRING[2]bit,bool):

BEGIN

MAKE COUNT\_SYNC[2]:blk\_count.

LET out = blk\_count[1].

JOIN (ck,reset,en) ->blk\_count.

OUTPUT(out,out EQ\_U (C\_TO\_S[2]col/3)[2])

END.

MOC

#the blk, or sub-band counters, carry out on 3, cout\_en enables the carry out, & cin\_en AND en enables the count#

FN BLK\_SUB\_COUNT = (bool:ck,t\_reset:reset, bool:en cin\_en cout\_en)      ->(STRING[2]bit,bool):

BEGIN

MAKE COUNT\_SYNC[2]:blk\_count.

LET out = blk\_count[1].

JOIN (ck,reset,en AND cin\_en)      ->blk\_count.

OUTPUT(out,(out EQ\_U (C\_TO\_S[2]col/3)[2]) AND cout\_en)

END.

FN LAST\_BLK\_COUNT = (bool:ck,t\_reset:reset, bool:en,t\_channel:channel,bool:line\_finished) ->

(STRING[2]bit,[2]bool#x\_en,y\_en#):

BEGIN

MAKE BASIC\_COUNT : lsb\_msb.

JOIN (ck,reset,en) ->lsb,

(ck,reset, CASE channel

```

OF y:lsb[2],
  u'v:line_finished
  ESAC) ->msb.
LET out = (msb[1]CONC(isb[1])).
OUTPUT (out, CASE channel
  OF y:(out EQ U (C TO S[2]col/3)[2],line_finished),
    u'v:(lsb[2],msb[2])
    ESAC)
END.
#the L1 norm calculator/ comparison constants& flag values#
#adding 4 absolute data values so result can grow by 2 bits#
#5 cycle sequence, a reset cycle with no data input, followed#
#by 4 data cycles#
MAC L1NORM = (bool:ck, t_reset:reset, STRING(INT n)bit:in) ->STRING(n+2)bit:
BEGIN
  MAKE DF1{STRING(n+4)bit}:in2.
  LET in_s=in,
    msb = ALL_SAME{n}(B TO Sin_s[1]),
  COM
    add_in1 = in2 CONC in_s[1], #in_s[1] is the carry in to the adder#
    #,lsb so gen carry to next bit#
    add_in2 = (in_s XOR_B msb)CONC in_s[1],
    #adder=ADD_U(add_in1,add_in2),#
  MOC
    add_in1 = (in_s XOR_B msb),
    rst_mux = CASE reset
      OF rst:ZERO(n+4)b'0"
      ELSE in2

```

```

ESAC,
adder=ADD_US_ACTEL(add_in1,rst_mux,CASE in_s[1]
  OF b'1:b'0
  ELSE b'1
  ESAC),
out =adder[2...(n+5)].

JOIN (ck,out) ->ln2.

OUTPUT in2[3..n+4]
END.

#the block to decide if all its inputs are all 0#
FN ALL_ZERO = (bool:ck, t_reset:reset, t_input:in) ->bool:
BEGIN
  MAKE DF1{bool}:out.

  LET in_s =(IN_TO_S(input_exp)ln)[2],

  in_eq_0 = in_s EQ_U ZERO(input_exp)b'0", #in =0#
  #1 if reset high, & OR with previous flag#
  all_eq_0 = CASE reset
  OF rst: in_eq_0
  ELSE CASE out
  OF tf
  ELSE in_eq_0
  ESAC
  ESAC.

```

```

JOIN (ck,all_eq_0)->out.
OUTPUT out
END.

MAC ABS_NORM = (bool:ck, t_reset:reset,STRING(result_exp-2]bit:qshift, STRING(INT n]bit:m)
->(STRING[n+2]bit,bool#all <qshift#):
BEGIN
  MAKE DF1{STRING[n+4]bit}:in2,
  DF1{bool}:out.
  LET abs_in = ABS_S in,
  rst_mux = CASE reset
    OF rst:ZERO[n+4]b'0"
    ELSE in2
    ESAC,
  adder = ADD_US_ACTEL(abs_in,rst_mux,b'1),
  add_s = adder[2..(n+5)],
  in_small = abs_in LT_U qshift,
  #1 if reset high, & OR with previous flag#
  all_small = CASE reset
    OF rst: 1
    ELSE CASE in_small
    OF ff
    ELSE out
    ESAC
    ESAC.

JOIN (ck,add_s) ->in2,
(ck,all_small) ->out.

OUTPUT (in2[3..n+4],out)

```

- 565 -

END.

```

#the decide fn block#
FN DECIDE = (bool:ck,t reset:reset,t_result:q_int,t_input:new old, t_result: threshold comparison,
             t_octave:octs,t_load:load_flags) ->[7]bool:
#nzflag,origin,noflag,ozflag,motion,pro_new_z,pro_no_z#
BEGIN
    MAKE1NORM(input_exp): oz,
    ABS_NORM(input_exp): nz,
    ABS_NORM(input_exp+1): no,
    LATCH([7]bool): flags.

    LET qshift=(1 TO SC(result_exp)q_int)[2][1..result_exp-2],
    #divide by 4 as test is on coeff values not block values#

    n_o=(IN_TO_S(input_exp)new)[2] SUB_S (IN_TO_S(input_exp)old)[2], #new-old, use from quant#
    nzflag = nz[1] LE_U (1 TO SC(result_exp)threshold)[2], #delay tests for pipelined data#
    noflag = no[1] LE_U (1 TO SC(result_exp)comparison)[2],
    ozflag = oz EQ_U ZERO(input_exp)b"0",
    origin = nz[1] LE_U no[1],
    nz_plus_oz = nz[1] ADD_U oz,

    pro_new_z = nz[2],

    pro_no_z = no[2],

    shift_add_sel = CASE DF1(t_octave)(ck,octs) #delay octs to match pipelin delay#
    OF oct/0:uno,

```



- 566 -

```

oct/1: dos,
oct/2: tres,
oct/3: quatro
    ESAC,
#keep 13 bits here to match no, keep msb's#
    shift_add= MUX_4{STRING[input_exp+3]bit}      #delay octs to match pipelin delay##
        nz_plus_oz{1..input_exp+3},
        b'0'CONC nz_plus_oz{1..input_exp+2},
        b'00'CONC nz_plus_oz{1..input_exp+1},
        b'000'CONC nz_plus_oz{1..input_exp},
        shift_add_sel
    },

    motion = shift_add LE_U no{1},
#value for simulation#
    nz_r = {SC_TO_I{12} nz{1}}{2},
    no_r = {SC_TO_I{13} no{1}}{2},
    oz_r = {SC_TO_I{12} oz}{2},
    sa_r = {SC_TO_I{13} shift_add}{2}.

JOIN (ck,reset,qshift,(IN_TO_S{input_exp}new){2}) ->nz,
    (load_flags,(nzflag,origin,noflag,ozflag,motion,pro_new_z,pro_no_z)) ->flags,
    (ck,reset,qshift,CAST{ STRING[input_exp+1]bit{no_o}} ->no,
    (ck,reset,(IN_TO_S{input_exp}old){2}) ->oz.
OUTPUT flags
END.
#the buffer for the FIFO#

#a pulse generator, glitch free#
FN PULSE = (bool:ck,t_reset:reset,t_load:in) ->t_load:

```

- 567 -

```

CASE (in, DFF{t_load})(ck, reset, in, read))
OF   (write, read): write
ELSE  read
ESAC.

#the length of the huffman encoded word#
FN LENGTH = (t_input: mag_out) -> STRING[5]bit:
CASE mag_out #length of inputoded word#
OF  Input/0: b"00001",
    Input/1: b"00011",
    Input/2: b"00100",
    Input/3: b"00101",
    Input/4: b"00110",
    Input/5: b"00111",
    Input/6: b"01000",
    Input/(7..21): b"01100"
ELSE  b"10000"
#  Input/(22..37): b"10000" #
ESAC.

FN REV_BITS = (STRING[8]bit: in) -> STRING[8]bit: CAST{STRING[8]bit} (in[8], in[7], in[6], in[5], in[4], in[3], in[2], in[1]).

FN FIFO_BUFFER = (bool: ck, t_reset: reset, t_direction: direction, t_cycle: cycle, t_mode: mode,
    t_input: value mag_out huff, STRING[16]bit: fifo_in, t_fifo: fifo_full fifo_empty,
    STRING[32]bit: shift, STRING[2]bit: token_length, bool: flush_buffer, t_quant: iprf_quant)
-> (STRING[16]bit, STRING[16]bit, STRING[16]bit, STRING[5]bit, t_load, t_load):
#fifo_out, s, fifo_read fifo_write#

BEGIN
MAKEDFF_INIT{STRING[16]bit}: low_word high_word,

```

```

DFF_INIT{STRING[5]bit}s,
DFF_INIT{t_high_low}:high_low,
MUX_2{STRING[16]bit}:high_in_low_in high_out_low_out.

```

```

LET dir_sel = CASE direction
                OF forward:left
                ELSE right
                ESAC,

```

```

length = CASE cycle
            OF token_cycle:b"000" CONC token_length,
               skip_cycle:b"00000",
               data_cycle: CASE mode #on LPP_STILL length fixed, given by input_exp-shift const#
                           OF lpf_still:((LEN_TO_U[5] len/input_exp)[2] SUB_U
                                (Q TO U[3] lpf_quant)[2])[2..6]
                           ELSE LENGTH_MUX_2(t_input)(value,mag_out_huff,dir_sel)
                           ESAC
            ESAC,

```

```

select_s = CASE direction
            OF forward:b"0" CONC s[2..5]
            ELSE s
            ESAC,

```

```

new_s = (ADD_US_ACTEL(select_s,length,b'1))[2..6], #6 bits#
#if new_s pointer > 16#
#on Inverse passed first 16 bits, active from [16,31] #

```

```

high_low_flag = new_s GE_U b"10000",

```

```

#forward#
fifo_not_full = CASE fifo_full
OF ok_fifo: write
ELSE read
ESAC,

fifo_write = CASE high_low #type change#
OF high: write
ELSE CASE flush_buffer #flush buffer when frame finished#
OF t: write #needs 2 cycles to clear#
ELSE CASE DFF{bool}(ck, reset, flush_buffer, f)
OF t: write
ELSE read
ESAC
ESAC,
#from inverse#

data_ready = CASE fifo_empty
OF ok_fifo: write
ELSE read
ESAC,

load_low = CASE reset #load low on reset to start things#
OF rst: write,
no_rst: PULSE(ck, reset, CASE (high_low_flag, data_ready) #load low word#
OF f, write): write
ELSE read
ESAC)

```

- 570 -

```

ELSE read
ESAC,
#delay reset for s and load_high#
reset_s = DFF(!reset)(ck,reset,reset,rst),

load_high = CASE reset_s #load high next#
OF rst:write,
no_rst: PULSE(ck,reset, CASE (high_low_flag,data_ready) #load high word#
OF (f,write):write
ELSE read
ESAC)
ELSE read
ESAC,

fifo_read = CASE load_low #read control for data_in FIFO#
OF write:read
ELSE CASE load_high
OF write:read
ELSE write
ESAC
ESAC,

#control signals#

(write_low,write_high) = CASE direction
OF forward:{2}fifo_not_full
ELSE (load_low,load_high)
ESAC,

(high_out_sel,low_out_sel) = CASE direction
OF forward:CASE high_low

```

- 571 -

```

OF   high: (left, right)
ELSE (right, left)
ESAC

```

```

ELSE [2]CAST(t_mux){s GE_U b'10000'}
ESAC.

```

JOIN

```

(shift[17..32],fifo_in_dir_sel)    ->high_in,
(shift[1..16],fifo_in_dir_sel)     ->low_in,
(high_word,low_word,high_out_sel)   ->high_out,
(low_word,high_word,low_out_sel)    ->low_out,
(ck,reset,write_low,low_in,ZERO{16}b'0') ->low_word,
(ck,reset,write_high,high_in,ZERO{16}b'0') ->high_word,
(ck,reset,fifo_not_full,CASE high_low_flag
  OF t:high
  ELSE low
  ESAC,low)    ->high_low,

(ck,CASE forward
  OF forward:reset
  ELSE reset s
  ESAC,CASE direction
  OF forward:fifo_not_full

```

- 572 -

```

ELSE data_ready
  ESAC, new_s, ZERO(5)b"0") ->s.

OUTPUT (low_word, low_out, high_out, s, fifo_read, fifo_write)
END.
#the HUFFMAN decode/encode function#

#a pulse generator, glitch free#

FN PULSE = (bool:ck, t_reset:reset, t_load:in) -> t_load:
CASE (in, DFF(t_load)(ck, reset, in, read))
OF (write, read):write
ELSE read
ESAC.

FN SHIFT32_16 = (STRING[32]bit:buffer, STRING[5]bit:s) -> STRING[16]bit:
#left justified value, s shift const#
BEGIN
  LET shift = (s AND B'b'01111')[2..5]. #input values rotated so always shift<16#
  OUTPUT
  CAST(STRING[16]bit)((INT j=1..16] MX16(CAST(STRING[16]bit)((INT i=1..16]buffer[i-1+i]), shift))
  END.

FN SHIFT16X16_32 = (STRING[16]bit:o n, STRING[4]bit:sel) -> STRING[32]bit:
BEGIN
  LET sel_mux4 = CASE sel[1..2]
    OF b'00':sel[3..4]
    ELSE b'11'

```

```

    ESAC,
    sel_mux4_high = CASE sel[1..2]
    OF b*11*:sel[3..4]
    ELSE b*00*
    ESAC,
    sel_mux8 = CASE sel[1]
    OF b'0*:sel[2..4]
    ELSE b*11*
    ESAC,
    sel_mux8_high = CASE sel[1]
    OF b'1*:sel[2..4]
    ELSE b*000*
    ESAC.

OUTPUT CAST{STRING[32]bit}(
    MX_4{bit}(n[1],o[1],o[1],o[1],o[1],CAST{[2]bool}sel_mux4),
    MX_4{bit}(n[2],n[1],o[2],o[2],CAST{[2]bool}sel_mux4),
    MX_4{bit}(n[3],n[2],n[1],o[3],CAST{[2]bool}sel_mux4),
    MUX_8{bit}(n[4],n[3],n[2],n[1],o[4],o[4],CAST{[3]bool}sel_mux8),
    MUX_8{bit}(n[5],n[4],n[3],n[2],n[1],o[5],o[5],CAST{[3]bool}sel_mux8),
    MUX_8{bit}(n[6],n[5],n[4],n[3],n[2],n[1],o[6],o[6],CAST{[3]bool}sel_mux8),
    MUX_8{bit}(n[7],n[6],n[5],n[4],n[3],n[2],n[1],o[7],CAST{[3]bool}sel_mux8),
    MX16(CAST{STRING[8]bit}((INT l=1..8)n[9..11]) CONC ALL SAME{8}B TO S o[8],sel[1..4]),
    MX16(CAST{STRING[9]bit}((INT l=1..9)n[10..11]) CONC ALL SAME{7}B TO S o[9],sel[1..4]),
    MX16(CAST{STRING[10]bit}((INT l=1..10)n[11..11]) CONC ALL SAME{6}B TO S o[10],sel[1..4]),
    MX16(CAST{STRING[11]bit}((INT l=1..11)n[12..11]) CONC ALL SAME{5}B TO S o[11],sel[1..4]),
    MX16(CAST{STRING[12]bit}((INT l=1..12)n[13..11]) CONC ALL SAME{4}B TO S o[12],sel[1..4]),
    MX16(CAST{STRING[13]bit}((INT l=1..13)n[14..11]) CONC ALL SAME{3}B TO S o[13],sel[1..4]),
    MX16(CAST{STRING[14]bit}((INT l=1..14)n[15..11]) CONC ALL SAME{2}B TO S o[14],sel[1..4]),

```



- 574 -

```

MX16(CAST{STRING[16]bit}((INT i=1..15[n[16-i]]CONC o[15]),sel[1..4]),
MX16(CAST{STRING[16]bit}((INT i=1..16[n[17-i]],sel[1..4]),
MX16(CAST{STRING[16]bit}(b'0 CONC (INT i=1..15[n[17-i]]),sel[1..4]),
MX16(ZERO[2]b'0" CONC CAST{STRING[14]bit}((INT i=1..14[n[17-i]],sel[1..4]),
MX16(ZERO[3]b'0" CONC CAST{STRING[13]bit}((INT i=1..13[n[17-i]],sel[1..4]),
MX16(ZERO[4]b'0" CONC CAST{STRING[12]bit}((INT i=1..12[n[17-i]],sel[1..4]),
MX16(ZERO[5]b'0" CONC CAST{STRING[11]bit}((INT i=1..11[n[17-i]],sel[1..4]),
MX16(ZERO[6]b'0" CONC CAST{STRING[10]bit}((INT i=1..10[n[17-i]],sel[1..4]),
MX16(ZERO[7]b'0" CONC CAST{STRING[9]bit}((INT i=1..9[n[17-i]],sel[1..4]),
MX16(ZERO[8]b'0" CONC CAST{STRING[8]bit}((INT i=1..8[n[17-i]],sel[1..4]),
MUX_8(bit)(b'0,n[16],n[15],n[14],n[13],n[12],n[11],n[10],CAST{[3]boolsel_mux8_high),
MUX_8(bit)(b'0,b'0,n[16],n[15],n[14],n[13],n[12],n[11],CAST{[3]boolsel_mux8_high),
MUX_8(bit)(b'0,b'0,b'0,n[16],n[15],n[14],n[13],n[12],CAST{[3]boolsel_mux8_high),
MUX_8(bit)(b'0,b'0,b'0,b'0,n[16],n[15],n[14],n[13],CAST{[3]boolsel_mux8_high),
MX_4(bit)(b'0,n[16],n[15],n[14],CAST{[2]boolsel_mux4_high),
MX_4(bit)(b'0,b'0,n[16],n[15],CAST{[2]boolsel_mux4_high),
MX_4(bit)(b'0,b'0,b'0,n[16],CAST{[2]boolsel_mux4_high),
b'0
)
END.
MAC REV_4 = (STRING[4]bit:in)      ->STRING[4]bit:CAST{STRING[4]bit}((n[4],n[3],n[2],n[1])).
#in is data from bus, fifo_empty is input fifo control#
FN HUFFMAN_DECODE = (t_mode:mode,STRING[2]bit:token_length_in,STRING[32]bit:buffer,STRING[5]bit:s)

```

```

->(bit_t_input,STRING[2]bit#token#):
BEGIN
    MAKESHIFT32_16:input_decode.
COM
    LET mag_out2 = CASE input_decode[9..12]
        OF b"1111":input_decode[13..16] ADD_U b"10110" #add 22 to give value#
        ELSE input_decode[9..12] ADD_U b"00111" #add 7 to give value#
        ESAC,
MOC
    LET sel_9_12 = CASE input_decode[9..12]
        OF b"1111":t
        ELSE f
        ESAC,
        mag_out2 = CASE sel_9_12
            OF t:REV_4 input_decode[13..16]
            ELSE REV_4 input_decode[9..12]
            ESAC ADD_U
                CASE sel_9_12
                OF t: b"10110" #add 22 to give value#
                ELSE b"00111" #add 7 to give value#
                ESAC,
        mag_out_huff = CASE input_decode[1]
            OF b'0:input/0
            ELSE CASE input_decode[3]
                OF b'1:input/1
                ELSE CASE input_decode[4]
                    OF b'1:input/2
                    ELSE CASE input_decode[5]
                        OF b'1:input/3

```

- 576 -

```

ELSE CASE input_decode[6]
  OF b'1::input/4
    ELSE CASE input_decode[7]
      OF b'1::input/5
        ELSE CASE input_decode[8]
          OF b'1::input/6
            ELSE (S_TO_IN (b'0000' CONC mag_out2))[2]
              ESAC
            ESAC
          ESAC
        ESAC
      ESAC
    ESAC
  ESAC,

#on lpf_still bit 1 is the sign bit#
sign = CASE mode
  OF lpf_still::input_decode[1]
    ELSE CASE mag_out_huff
      OF input/0:b'0
        ELSE input_decode[2]
          ESAC
        ESAC,

#select huff value, 0(in lpf_send) or real value, rearrange the bits for real data#
#on lpf_still bit 1 is sign bit so discard#
mag_out = CASE mode
  OF lpf_still:(S_TO_IN (CAST(String[9]bit)[INT | =1..9]input_decode[11-1]))[2]
    ELSE mag_out_huff
      ESAC,

```

- 577 -

```

token_length = b'000'CONC token_length_in,

#decode token, valid only during a token cycle#
token = CASE token_length[4..5]
  OF b'10':input_decode[1..2],
   b'01':input_decode[1] CONC b'0'
  ESAC.

JOIN (buffer,s) ->input_decode.

OUTPUT (sign,mag_out,token)
END.

#the huffman encoder#
FN HUFFMAN_ENCODE = (t_input:value,bit:sign,STRING[2]bit:token,t_mode:mode,t_cycle:cycle,
  STRING[16]bit:buffer,STRING[5]bit:s)
  ->(STRING[32]bit):
BEGIN
  MAKE SHIFT16X16_32:shift.
  #encode value#
  LET header = CAST{STRING[2]bit}(b'1,sign).

  value_bit = CAST{[16]bit}(IN_TO_S[16] value)[2],

  sub_const = CASE value
    OF input/(7..21):b'00111',
     input/(22..37):b'10110'
    ELSE b'00000'
  ESAC,

```

```

sub_value = (IN_TO_S(input_exp)value)[2] SUB_U sub_const)[8..11],
enc_value=

CASE cycle
OF token_cycle: token CONC ZERO(14)b"0", #token is msb, max 2 bits#
data_cycle: CASE mode
#on intra & LPF: pass thro value as 16 bit word, and reverse bit order, place sign first next to lsb#
OF lpf_still: CAST{STRING(1)bit} sign CONC CAST{STRING(15)bit} (INT [1..15]value_bit[17-i])
#otherwise value is to Huffman encoded, so out 16 bit as this is the max, the shift removes the extra bits#
ELSE CASE value
OF input/0: b"0" CONC ZERO(15)b"0",
input/1: header CONC b"1" CONC ZERO(13)b"0",
input/2: header CONC b"01" CONC ZERO(12)b"0",
input/3: header CONC b"001" CONC ZERO(11)b"0",
input/4: header CONC b"0001" CONC ZERO(10)b"0",
input/5: header CONC b"00001" CONC ZERO(9)b"0",
input/6: header CONC b"000001" CONC ZERO(8)b"0",

input/(7..21): header CONC b"000000" CONC (REV_4 sub_value) CONC ZERO(4)b"0", #sub 7 to give value#

input/(22..37): header CONC b"00000001111" CONC (REV_4 sub_value) #sub 22 to give value#

ELSE header CONC b"000000011111111"
ESAC

ESAC,

skip_cycle: ZERO(16)b"0" #dummy value#
ESAC.

```

```
JOIN (buffer_enc_value,s[2..5]) ->shift.
```

```
#max value is 37 so 8 bits enough#
OUTPUT shift
END.
```

```
# some basic macros for the convolver, assume these will#
#be synthesised into leaf cells#
MAC MX_4(TYPE ty)=(ty:in1 in2 in3 in4, [2]bool:sel) ->ty:
```

```
CASE sel
OF (f,f):in1,
   (f,f):in2,
   (f,f):in3,
   (f,f):in4
ESAC.
```

```
MAC ENCODE4_2 = (l_mux4:in) ->[2]bool:
```

```
CASE in
OF uno:(f,f),
   dos:(f,f),
   tres:(f,f),
   quatro:(f,f)
ESAC.
```

```
MAC ENCODE3_2 = (l_mux3:in) ->[2]bool:
```

```
CASE in
OF l:(f,f),
   c:(f,f),
```

- 580 -

r:(t,f)  
ESAC.

MAC\_MUX\_3(TYPE t)=(t:in1 in2 in3 , t\_mux3:sel) ->t:  
MX\_4(t)(in1,in2,in3,in1,ENCODE3\_2 sel).

MAC\_MUX\_4(TYPE t)=(t:in1 in2 in3 in4, t\_mux4:sel) ->t:  
MX\_4(t)(in1,in2,in3,in4,ENCODE4\_2 sel).

MAC\_MUX\_2(TYPE t)=(t:in1 in2, t\_mux:sel) ->t:  
CASE sel  
OF left:in1,  
right:in2  
ESAC.

MAC\_MUX\_8(TYPE ty)=(ty:in1 in2 in3 in4 in5 in6 in7 in8, [3]bool:sel) ->ty:  
CASE sel  
OF (f,f,f):in1,  
(f,f,t):in2,  
(f,t,f):in3,  
(f,t,t):in4,  
(t,f,f):in5,  
(t,f,t):in6,  
(t,t,f):in7,  
(t,t,t):in8  
ESAC.

MAC\_MX16=(STRING[16]bit:in, STRING[4]bit:sel) ->bit:  
CASE sel  
OF b"0000":in[1],  
b"0001":in[2],

```

b"0010":in[3],
b"0011":in[4],
b"0100":in[5],
b"0101":in[6],
b"0110":in[7],
b"0111":in[8],
b"1000":in[9],
b"1001":in[10],
b"1010":in[11],
b"1011":in[12],
b"1100":in[13],
b"1101":in[14],
b"1110":in[15],
b"1111":in[16]
ESAC.
COM
MAC MX16=(STRING[16]bit:n, STRING[4]bit:sel) ->bit:
MUX_2(bit){
  MUX_8(bit){in[1],in[2],in[3],in[4],in[5],in[6],in[7],in[8],CAST({3}bool)sel[2..4]},
  MUX_8(bit){in[9],in[10],in[11],in[12],in[13],in[14],in[15],in[16],CAST({3}bool)sel[2..4]},
  CASE sel[1]
  OF b'0:left
  ELSE right
  ESAC).
MOC

MAC INT_BOOL = (t_quant:q) -> [3]bool:
CASE q
OF quant/0:(f,f,f),
  quant/1:(f,f,f),
  quant/2:(f,f,f),

```



- 582 -

```

quant/3:(t,t,t),
quant/4:(t,t,t),
quant/5:(t,t,t),
quant/6:(t,t,t),
quant/7:(t,t,t)
ESAC.

```

```

COM

```

```

MAC MUX_3(TYPE t)=(t:in1 in2 in3, t_mux3:sel) ->t:

```

```

CASE sel

```

```

OF in1,

```

```

   c:in2,

```

```
   r:in3

```

```

ESAC.

```

```

MAC MUX_4(TYPE t)=(t:in1 in2 in3 in4, t_mux4:sel) ->t:

```

```

CASE sel

```

```

OF uno:in1,

```

```
   dos:in2,

```

```
   tres:in3,

```

```
   quatro:in4

```

```

ESAC.

```

```

MOC

```

```

FN NOT = (bool:in)->bool:CASE in OF t:f ESAC.

```

```

FN XOR = (bool: a b) ->bool:

```

```

CASE (a,b)

```

```

OF (t,f)(t,t):f

```

```

ELSE t

```

```

ESAC.

```

```

FN AND = (bool: a b) ->bool:
CASE (a,b)
OF (t,t):t,
   (f,bool)||(bool,f):f
ESAC.

```

```

FN OR = (bool: a b) ->bool:
CASE (a,b)
OF (f,f):f,
   (t,bool)||(bool,t):t
ESAC.

```

```

MAC DEL(TYPE t) = (t) ->t:DELAY(?t,t).

```

```

#a general d latch#
MAC LATCH (TYPE t)=(t_load:load,t:in) ->t:
BEGIN
MAKE DEL(t):del.
LET out=CASE load
OF write:in
ELSE del
ESAC.
JOIN out->del.
OUTPUT out
END.

```

```

#a general diff#
MAC DF1 (TYPE t)=(bool:ck,t:in) ->t:
BEGIN
MAKE DEL(t):del.

```

- 584 -

```

JOIN in->del.
OUTPUT del
END.

```

```

#a resetable DFF, init value is input parameter#
MAC DFF_INIT(TYPE t)=(bool:ck,t_reset:reset,t_load:load,t_in init_value) ->t:
BEGIN
  MAKE DEL(t):del.
  LET out=CASE (load,reset)
    OF (write,t_reset):in,
      (read,rst):init_value
    ELSE del
    ESAC.
  JOIN out->del.
  OUTPUT CASE reset
    OF rst:init_value
    ELSE del
    ESAC
  END.

```

```

#a dff resetable non-loadable dff#
MAC DFF(TYPE t)=(bool:ck,t_reset:reset,t_in init_value) ->t:
BEGIN
  MAKE DEL(t):del.
  JOIN in->del.
  OUTPUT CASE reset
    OF rst:init_value
    ELSE del
    ESAC
  END.

```

```

MAC PDEL(TYPE t,INT n) = (t:in) ->t:
  IF n=0 THEN DEL({})in
  ELSE PDEL({t,n-1}) DEL({}) in
  FI.

MAC PDF1(TYPE t,INT n) = (bool:ck,t:in) ->t:
  IF n=0 THEN DF1({})(ck,in)
  ELSE PDF1({t,n-1})(ck,DF1({})(ck,in))
  FI.

#generates the new_mode from the old, and outputs control signals to the tokeniser#

FN MODE_CONTROL = (bool:ck, t_reset:reset, t_intra:intra_inter,bool:pf_done,[7]bool:flags,
  STRING[2]bit:token_in,t_octave:octave,t_state:state,t_direction:direction,t_load:load_mode_in
  ,t_cycle:cycle)
  ->(t_mode,t_mode,STRING[2]bit,t_diff,STRING[2]bit,t_mode):
#new_mode,proposed mode,current token,difference,token_length,#
BEGIN

  MAKE [4]DFF_INIT(t_mode):mode,
  DFF_INIT(t_diff):diff_out,
  DFF_INIT(t_mode):next_mode.
  LET nzflag=flags[1],
  origin=flags[2],
  noflag=flags[3],
  ozflag=flags[4],
  motion=flags[5],
  pro_new_z = flags[6],
  pro_no_z = flags[7],

```

- 586 -

```

lpf_done_del = DFF(bool)(ck,reset,lpf_done,f).    #synchronise mode change at end of LPF#

LET next = (SEQ
#the proposed value for the mode at that octave, flags etc will change this value as necessary#
#proposed, or inherited mode from previous tree#

    VAR pro_mode:= CASE reset
      OF rst:CASE intra_inter    #reset on frame start, so do lpf#
        OF intra:lpf_still
          ELSE lpf_send
            ESAC
        ELSE CASE lpf_done_del
          OF:CASE intra_inter    #store default mode in mode[4]#
            OF intra:still
              ELSE send
                ESAC
            ELSE CASE state
              OF down1:mode[3], #jump sideways in oct/1#
                , up0:mode[4]
              ELSE CASE octave
                OF oct/0:mode[1],
                  oct/1:mode[2],
                  oct/2:mode[3]
                  ESAC
                ESAC
                ESAC
              ESAC,
              new_mode:=pro_mode,    #inherit the previous mode#
              token_out:=b"00",

```

- 587 -

```

        difference:=nodiff,
        token_length:=b"00",
        flag:=f;
CASE direction
OF forward:

CASE pro_mode
OF void:CASE ozflag
OF t:new_mode:=stop
ELSE
ESAC,      #stay in these modes until end of tree#

void_still:.,      #intra so must zero out all of tree#

still_send:(token_length:=b"01";
CASE (nzflag OR pro_new_z)
OF t:(token_out:=b"00";
CASE ozflag
OF t:new_mode:=stop
ELSE new_mode:=void
ESAC)
ELSE (token_out:=b"10";
new_mode:=still_send)
ESAC

),

send: CASE ozflag
OFT:(token_length:=b"01";

CASE (nzflag OR pro_new_z)

```

```

OF t:(token_out:=b'00";
  new_mode:=stop)
ELSE (token_out:=b'10";
  new_mode:=still_send)
ESAC
)
ELSE (token_length:=b'10";

CASE ( NOTnzflag OR motion) AND NOTnzflag)
OFt:( CASE origin
  OF t:flag:=pro_new_z
  ELSE (flag:=pro_no_z;
    difference:=diff)
  ESAC;
CASE flag
OFt:(token_out:=b'10";
  new_mode:=void)
ELSE CASE origin
  OFt:(token_out:=b'01";
    new_mode:=still_send)
  ELSE (token_out:=b'11";
    new_mode:=send)
  ESAC
ESAC)
ELSE

CASE (motion OR origin)AND nzflag
OFt:(token_out:=b'10";
  new_mode:=void)
ELSE (token_out:=b'00";
  new_mode:=stop)

```

```

        ESAC
        ESAC
    )
    ESAC,

```

```

still: (token_length:=b'01";
CASE (nzflag OR pro_new_z)
OF t:(token_out:=b'00";
    new_mode:=void_still) #zero out tree#
ELSE (token_out:=b'10";
    new_mode:=still)
ESAC
),
(lpf_still):(token_out:=b'00";
    token_length:=b'00"),
(lpf_send):(difference:=diff;
    token_length:=b'01";

CASE (noflag OR pro_no_z)
OF t:(token_out:=b'00";
    new_mode:=lpf_stop)
ELSE (token_out:=b'10";
    new_mode:=lpf_send) #as mode stop but for this block only#
ESAC)
ESAC,

```

```

inverse:
CASE pro_mode

```



```

OF void: CASE ozflag
  OF t:new_mode:=stop
  ELSE
  ESAC,

void_still: ,

send: CASE ozflag
  OF t:(token_length:=b'01"; #repeat of still-send code#
    CASE token_in[1]
    OF b'1:new_mode:=still_send,
      b'0:new_mode:=stop
    ESAC
  )
ELSE (token_length:=b'10";
  CASE token_in
  OF b'11": (difference:=diff;
    new_mode:=send),
    b'01":new_mode:=still_send,
    b'10":new_mode:=void,
    b'00":new_mode:=stop
  ESAC
  )
ESAC,

still_send: (token_length:=b'01";
  CASE token_in[1]
  OF b'1:new_mode:=still_send,
    b'0: CASE ozflag
      OF t:new_mode:=stop

```

- 591 -

```

ELSE new_mode:=void
ESAC
ESAC
),
still: (token_length:=b'01";
CASE token_in[1]
OF b'1:new_mode:=still,
b'0:new_mode:=void_still
ESAC
),
(lp_send):(difference:=diff;
token_length:=b'01";
CASE token_in[1]
OF b'0:new_mode:=lpf_stop,
b'1:new_mode:=lpf_send
ESAC),
lpf_still:
ESAC
ESAC;

OUTPUT (new_mode,pro_mode,token_out,difference,token_length)
).

LET load_mode = CASE (reset,lpf_done_def) #store base mode in mode[3]& mode[4], base changes after lpf#
OF (rst,bool):(t_reset,t):(read,read,write,write)
ELSE CASE (octave,load_mode_in)

```

```

OF   (oct/1,write):(write,write,read,read),
      (oct/2,write):(read,write,write,read)
ELSE (read,read,read,read)
ESAC
      ESAC.
#save the new mode& difference during a token cycle, when the flags and tokens are valid#
JOIN  (ck,reset,CASE cycle
      OF token_cycle:write
      ELSE read
      ESAC, next[1],still)      ->next_mode,

      (ck,reset,CASE cycle
      OF token_cycle:write
      ELSE read
      ESAC, next[4],nodiff)      ->diff_out.

#now write the new mode value into the mode slack at end of cycle, for later use #
FOR INT l = 1..4 JOIN (ck,no_rst,load_mode[l],CASE (reset,lpf_done_del)
      OF (no_rst,1)/((rst,bool):next[2]
      ELSE next_mode
      ESAC,still) ->mode[l].
#dont update modes at tree base from lpf data, on reset next[1] is undefined#

OUTPUT (next_mode,next[2],next[3],diff_out,next[5],next[1])
END.

#the tree coder chip#
#threshold = 2^quant_norm#

FN PALMAS= (bool:ck,t_reset:reset,t_direction:direction,t_intra:intra_inter,t_channel_factor:channel_factor,

```

- 593 -

```
[4]t_quant:quant_norm, STRING[16]bit:buffer_in,
t_input:new_old,[4]t_result:threshold, t_fifo:full_fifo_empty, STRING[xsize]bit:col_length,
STRING[ysize]bit:row_length, STRING[xsize]bit:ximage_string, #ximage#
STRING[ysize]bit:yimage_string, STRING[11]bit:yimage_string_3#yimage&yimage*2.5#)
```

```
->(t_input,t_sparc_addr,(t_load,t_cs),(t_load,t_cs),STRING[16]bit,[2]t_load,bool,t_cycle):
```

```
#old,address,(rw_new,cs_new),(rw_old,cs_old),buffer_out,t_fifo_read_fifo_write, cycle#
```

```
BEGIN
```

```
MAKEDECIDE:decide,
```

```
ADDR_GEN:addr_gen,
```

```
HUFFMAN_ENCODE:huffman_encode,
```

```
FIFO_BUFFER:fifo_buffer,
```

```
HUFFMAN_DECODE:huffman_decode,
```

```
MODE_CONTROL:mode,
```

```
CONTROL_COUNTER:control_counter,
```

```
BLK_SUB_COUNT:sub_count,
```

```
OFF_INIT(t_channel):channel,
```

```
QUANT:quant.
```

```
LET
```

```
nzflag=decide[1],
```

```
origin=decide[2],
```

```
nzflag=decide[3],
```

```
ozflag=decide[4],
```

```
motion=decide[5],
```

```
pro_no_z = decide[7], #pro_no_z or pro_new_z#
```

```
pro_new_z = decide[6],
```

```

new_mode = mode[1],
pro_mode = mode[2],
token_out = mode[3],
difference = mode[4],
token_length = mode[5],

pro = quant[1], #pro_no, or pro_new#
lev_out = (S_TO_IN quant[2])[2], #corresponding level#
sign = quant[3], #and sign #

ocls = addr_gen[2],
sub_en = addr_gen[3],
tree_done = addr_gen[4],
lpf_done = addr_gen[5],
state = addr_gen[6],

cycle = control_counter[2],
cs_new = control_counter[7],
rw_new = read,
rw_old = control_counter[8],
cs_old = control_counter[9],

load_channel = CASE (sub_en, sub_count[2]) #change channel#
  OF (t.i): write
  ELSE read
  ESAC,

new_channel = CASE channel_factor
  OF luminance: y
  ELSE CASE channel
    OF yu,

```

```

    u:v,
    v:y
    ESAC
    ESAC,
    #flush the buffer in the huffman encoder#
    flush_buffer = DFF{bool}{ck,reset,CASE channel_factor
    OF luminance:CASE load_channel
    OF write:t
    ELSE f
    ESAC,
    color: CASE (channel,load_channel)
    OF (v,write):t
    ELSE f
    ESAC
    ESAC,f),

    frame_done = PDF1{bool,1}{ck,flush_buffer),

    fifo_write=fifo_buffer[6],
    fifo_read =fifo_buffer[5],
    s=fifo_buffer[4],

    buffer_out = fifo_buffer[1],

    lev_in = huffman_decode[2],
    sign_in = huffman_decode[1],
    token_in = huffman_decode[3],

    del_new = PDF1{t_input,4}{ck,new),

```

- 596 -

```

#old has variable delays for inverse#
del_old = CASE (direction,pro_mode)
  OF (forward,t_mode){(inverse,send|still_send|pf_send|void): PDF1(t_input,4){ck,old}
  ELSE PDF1(t_input,1){ck,old}
  ESAC,
decide_reset=CASE reset
  OF rst:rst
  ELSE control_counter[3]
  ESAC,

oct_sel = CASE pro_mode
  OF pf_still|pf_send|pf_stop:quatro
  ELSE CASE (octs,channel)
    OF (oct/0,y):uno,
      (oct/1,y){(oct/0,u|v):dos,
        (oct/2,y){(oct/1,u|v):tres
      ESAC
    ESAC,

threshold_oct = MUX_4(t_result){(threshold[1],threshold[2],threshold[3],threshold[4],oct_sel),

quant_oct = MUX_4(t_quant){quant_norm[1],quant_norm[2],quant_norm[3],quant_norm[4],oct_sel}.

JOIN (ck,decide_reset,threshold_oct,new,old,threshold_oct,threshold_oct,octs,control_counter[6])->decide,
(ck,reset,intra_inter,lpf_done,decide,token_in,octs,state,direction,control_counter[1],cycle)->mode,

#delay the new&old values by 5 or 1 depending on mode & direction#
((IN TO S[input_exp|del_new][2], (IN TO S[input_exp|del_old][2],
  (IN TO S[input_exp|lev_in][2], sign_in,direction,quant_oct,difference,pro_mode) ->quant,

```

```

(ck,reset,new_channel,channel,load_channel,sub_count[1],col_length,row_length,
ximage_string,yimage_string,yimage_string_3,control_counter[4],control_counter[5],new_mode)->addr_gen,

(ck,reset,direction,cycle,pro_mode,lev_out,huffman_decode[2],buffer_in,fifo_full,
fifo_empty,huffman_encode,token_length,flush_buffer,quant_norm[4])      ->fifo_buffer,

(lev_out,sign,token_out,pro_mode,cycle,fifo_buffer[2],s)      ->huffman_encode,

(pro_mode,token_length,fifo_buffer[2] CONC fifo_buffer[3],fifo_buffer[4])  ->huffman_decode,

(ck,reset,sub_en,t,t)      ->sub_count,

(ck,reset,pro_mode,new_mode,direction)      ->control_counter,

(ck,reset,load_channel,new_channel,y)      ->channel.

OUTPUT

(CASE new_mode
OF void|void_still:input/0
ELSE (S TO INpro)[2]
ESAC      ,addr_gen[1],(rw_new,cs_new),(rw_old,cs_old),buffer_out,(fifo_read,fifo_write),frame_done,cycle)
END.
COM
#the decoder for the barrel shifter-- decides if the bit value and q value are #
#in the upper-triangle, or diagonal and set the control bits      #
MAC DECODE(INT n) = (t_quant:q)  ->[qmax](bool#upper diag#,bool#diagonal#):
BEGIN
#one bit of the decoder#
MAC DECODE_BIT(INT j)= (t_quant:q)  ->(bool,bool):
CASE q

```



```

OF quant/(0..qmax-1):(f,f), #upper-triangle#
  quant/(qmax-1+1):(f,f) #diagonal#
ELSE (f,f)
ESAC.
OUTPUT((INT j=1..qmax)DECODE_BIT[j](q))
END.

#now the selector fn to mux between the data_in bit_0 or 1 depending on q#
MAC SELECTOR = (f_quant:q,STRING(INT n)bit:data)
  ->(STRING[n]bit#level#,STRING[n]bit#round_level#):
BEGIN
  #the 3->2 bit selector#
  MAC SELECT_BIT = ((2)bool:upper_or_diag,bit:data)  ->(bit,bit):#level#,round_level##
  CASE upper_or_diag
  OF (f,f):(data,data), #upper-triangle#
    (f,f):(b'0,b'0) #diagonal#
  ELSE (b'0,b'1) #lower-triangle#
  ESAC.
  MAKE DECODE(n):decode,
    [qmax]SELECT_BIT:select.
  JOIN (q) ->decode.

  FOR INT j=1..qmax JOIN (decode[j],data[n-qmax+j]) ->select[j].

  OUTPUT (data[1..n-qmax] CONC (BIT_STRING(qmax)((INT j=1..(qmax))select[j][1])), #level#
    data[1..n-qmax] CONC (BIT_STRING(qmax)((INT j=1..(qmax))select[j][2])) #round_level#
  )
END.
MOC

#now the selector fn to shift the level depending on q#

```

MAC BARREL\_SHIFT\_RIGHT = (t\_quant:q, STRING(INT n)bit:data) ->(STRING(n)bit#level#):  
 MUX\_8(STRING(n)bit){

data,

b"0"CONC data[1..n-1],

b"00"CONC data[1..n-2],

b"000"CONC data[1..n-3],

b"0000"CONC data[1..n-4],

b"00000"CONC data[1..n-5],

b"000000"CONC data[1..n-6],

b"0000000"CONC data[1..n-7],

INT\_BOOL q).

#the bshift for the inverse, to generate the rounded level #

MAC BARREL\_SHIFT\_LEFT = (t\_quant:q, STRING(INT n)bit:data#lev#) ->(STRING(n)bit#round\_level#):

MUX\_8(STRING(n)bit){

data,

data[2..n]CONCb"0",

data[3..n]CONCb"01",

data[4..n]CONCb"011",

data[5..n]CONCb"0111",

data[6..n]CONCb"01111",

data[7..n]CONCb"011111",

data[8..n]CONCb"0111111",

INT\_BOOL q).

#the function to return the quantised level(UNSIGNED), and proposed value given,#

# the new&old values, forw/inverse direction #

FN QUANT = (STRING(input\_exp)bit: new old lev \_inv,bit:sign \_lev \_inv, t\_direction:direction,t\_quant:q,t\_diff:diffence,  
 t\_mode:mode)

- 600 -

-> (STRING[input\_exp]bit,STRING[input\_exp]bit) #pro,lev& sign# :

BEGIN

LET

#decide which of new-old or new will be quantised, and the sign of the level#  
#level is stored in sign & magnitude form#

dir\_sel = CASE direction  
OF forward:left,  
inverse:right  
ESAC,

sub\_sel = CASE difference  
OF diff:left  
ELSE right #put old=0#  
ESAC,

sub\_in= MUX\_2{STRING[input\_exp]bit}{old,ZERO[input\_exp]b"0",sub\_sel},

no =ADD\_SUB\_ST(new,sub\_in,subt),

lev\_final= ABS\_S no, #now input\_exp+1 bits#

sgn\_level= MUX\_2{bit}{ #sign of value to be quantised#  
no[1],  
sign\_lev\_inv,  
dir\_sel}.

- 601 -

#find the quant. level by shifting by q, for the inverse it comes from the Huffman decoder#

```

LET
  lev_data = BARREL_SHIFT_RIGHT(q,lev_final),

  #saturate the lev at 37, for the Huffman table,except in lpf_still mode, send all the bits#
  lev_forw = CASE mode
    OF lpf_still:lev_data
    ELSE CASE lev_data GT_U b"000000100101"
      OF t:b"00000100101"
        ELSE lev_data
      ESAC
    ESAC,

```

```

lev = MUX_2(STRING[input_exp+1]bit){
  lev_forw,
  b"0" CONC lev_inv,
  dir_sel),
  #the level = 0 flag#
  lev_z = lev EQ_U ZERO(input_exp+1)b"0",

```

```

  inv_lev_z = CASE lev_z
    OF t:b'0
      ELSE b'1
    ESAC,

```

```

#the level value shifted up, and rounded#
round_lev = BARREL_SHIFT_LEFT(q,lev) AND_B
CASE mode
  OF lpf_still:b"00" CONC ALL_SAME(input_exp-1)b"1"
  ELSE BIT_STRING(input_exp+1)(input_exp+1)inv_lev_z) #if lev==0 out all 0's#

```

```

        ESAC,
        #clear out extra bit for lpf still case#

        #calculate the proposed value:in the case n-o,round_lev is unsigned 10 bit, so result needs 11 bits#
        #pro_no will always be in range as round_lev<[n-o]_#

        pro_no = ADD_SUB_ST(old,round_lev,CASE sgn_level
            OFb'0':add,
            b'1':subt
            ESAC),

        #now pro_new = +/- round_lev#

        round_sel = CASE sgn_level
            OFb'0': left,
            b'1': right
            ESAC,

        pro_new = MUX_2{STRING[input_exp+1]bit}(
            round_lev,
            (NEG_U round_lev)[2..input_exp+2], #NEG sign extends#
            round_sel),

        out_sel = CASE difference
            OFdiff:left
            ELSE right
            ESAC.

        OUTPUT (MUX_2{STRING[input_exp]bit}(

```

```

    pro_no[3..input_exp+2],
    pro_new[2..input_exp+1],
    out_sel),
    lev[2..input_exp+1],
    sgn_level)

```

```

END.
#actel 1 bit full adder with active low cin and cout#
FN FA1B = (bit: ain bin cinb) -> (bit,bit):#cob,s#
BEGIN
  LET a_c=B TO S ain CONC NOT_B(B_TO_S cinb),
      b_c=B TO S bin CONC NOT_B(B_TO_S cinb),
      out = ADD_U(a_c,b_c).
  OUTPUT(CAST{bit} NOT_B(B_TO_S out[1]), out[2])
END.

```

```

#A Ripple carry adder using 1 bit full adder blocks#

```

```

#the actel version of the ADD BIOP's#

```

```

MAC ADD S_ACTEL = (STRING(INT m)bit:ain,STRING(INT n)bit:bin,bit:cinb) ->STRING[IF m>=n THEN m+1 ELSE n+1 F]bit:
BEGIN
  MAKE [IF m>=n THEN m ELSE n F]FA1B:sum.

```

```

#signed nos so sign extend #
LET a_c = IF m>=n THEN ain ELSE ALL_SAME(n-m)B TO S ain[1] CONC ain FI,
      b_c = IF n>=m THEN bin ELSE ALL_SAME(m-n)B TO S bin[1] CONC bin FI.
LET subsignal = sum.
#lsb#

```

```

JOIN  (a_c[(IF m>=n THEN m ELSE n FI)],b_c[(IF m>=n THEN m ELSE n FI),c1nb) ->sum[(IF m>=n THEN m ELSE n FI)].

FOR INT j=1..(IF m>=n THEN m ELSE n FI) -1
JOIN (a_c[(IF m>=n THEN m ELSE n FI) -j],b_c[(IF m>=n THEN m ELSE n FI) -j],
sum[(IF m>=n THEN m ELSE n FI) -j+1][1]) ->sum[(IF m>=n THEN m ELSE n FI) -j].

OUTPUT CAST(STRING[(IF m>=n THEN m+1 ELSE n+1 FI)bit]
(NOT B(B TO S sum[1][1]) CONC
CAST(STRING[(IF m>=n THEN m ELSE n FI)bit]([INT j=1..IF m>=n THEN m ELSE n FI] sum[j][2]))
END.

MAC ADD_US_ACTEL = (STRING([INT m]bit:ain,STRING([INT n]bit:bin,bit:c1nb) ->STRING[(IF m>=n THEN m+1 ELSE n+1 FI)bit]
BEGIN
MAKE [(IF m>=n THEN m ELSE n FI)FA1B:sum.

#unsigned nos so extend by 0#
LET a_c = IF m>=n THEN ain ELSE ZERO(n-m)b"0" CONC ain FI,
b_c = IF n>=m THEN bin ELSE ZERO(m-n)b"0" CONC bin FI.
LET subsignal = sum.

#lsb#
JOIN (a_c[(IF m>=n THEN m ELSE n FI)],b_c[(IF m>=n THEN m ELSE n FI),c1nb) ->sum[(IF m>=n THEN m ELSE n FI)].

FOR INT j=1..(IF m>=n THEN m ELSE n FI) -1
JOIN (a_c[(IF m>=n THEN m ELSE n FI) -j],b_c[(IF m>=n THEN m ELSE n FI) -j],
sum[(IF m>=n THEN m ELSE n FI) -j+1][1]) ->sum[(IF m>=n THEN m ELSE n FI) -j].

OUTPUT CAST(STRING[(IF m>=n THEN m+1 ELSE n+1 FI)bit]
(NOT B(B TO S sum[1][1]) CONC
CAST(STRING[(IF m>=n THEN m ELSE n FI)bit]([INT j=1..IF m>=n THEN m ELSE n FI] sum[j][2]))

```

END.

MAC\_ADD\_SUB\_ST = (STRING[INT m]bit:ain, STRING[INT n]bit:bin, t\_add:sel) -> STRING[IF m>=n THEN m+1 ELSE n+1 FI]bit:

BEGIN

#sign extend inputs#

LET a\_s = CAST{STRING[1]bit}ain[1] CONC ain,

b\_s = CAST{STRING[1]bit}bin[1] CONC bin,

sel\_bit = CAST{STRING[1]bit}sel,

#ACTEL#

bin\_inv = XOR\_B[n+1](b\_s, ALL\_SAME[n+1]sel\_bit),

#cinb is active low so cast sel(add->0,sub->1) & Invert it#

out\_ = ADD\_S\_ACTEL(a\_s, bin\_inv, CAST{bin}NOT\_B sel\_bit),

binout\_ = out[2..IF m>=n THEN m+2 ELSE n+2 FI]

OUTPUT binout

END.

#transformation ops#

MAC\_B\_TO\_S = (bit:in) -> STRING[1]bit: CASE in

OF b'0:b'0",

b'1:b'1"

ESAC.

MAC\_I\_TO\_SC[INT n] = (t\_result:in) -> (flag,t\_input): BIOP\_TRANSFORM\_S.

MAC\_SC\_TO\_I[INT n] = (STRING[n]bit:in) -> (flag,t\_result): BIOP\_TRANSFORM\_S.

MAC\_S\_TO\_IN = (STRING[INT n]bit:in) -> (flag,t\_input): BIOP\_TRANSFORM\_S.

MAC\_IN\_TO\_S[INT n] = (t\_input:in) -> (flag,STRING[n]bit): BIOP\_TRANSFORM\_S.



```

MAC U_TO_IN = (STRING[INT n]bit:in) -> (flag,t_input): BIOP TRANSFORM_US.

MAC U_TO_LEN = (STRING[INT n]bit:in) -> (flag,t_length): BIOP TRANSFORM_US.
MAC LEN_TO_U[INT n] = (t_length:in) -> (flag,STRING[n]bit): BIOP TRANSFORM_US.

MAC Q_TO_U[INT n] = (t_quant:in) -> (flag,STRING[n]bit): BIOP TRANSFORM_US.
MAC S_TO_C = (STRING[INT n]bit:in) -> (flag,t_col): BIOP TRANSFORM_US.
MAC S_TO_R = (STRING[INT n]bit:in) -> (flag,t_row): BIOP TRANSFORM_US.
MAC S_TO_B = (STRING[INT n]bit:in) -> (flag,t_blk): BIOP TRANSFORM_US.
MAC S_TO_SUB = (STRING[INT n]bit:in) -> (flag,t_sub): BIOP TRANSFORM_US.
MAC S_TO_SPARC = (STRING[INT n]bit:in) -> (flag,t_sparc_addr): BIOP TRANSFORM_US.

MAC C_TO_S[INT n] = (t_col: in) -> (flag,STRING[n]bit): BIOP TRANSFORM_US.
MAC R_TO_S[INT n] = (t_row: in) -> (flag,STRING[n]bit): BIOP TRANSFORM_US.

MAC I_TO_Q = (t_input:in) -> t_quant: ARITH in.

MAC B_TO_I = (bit:in) -> t_result: CASE in
  OF b'0: result/0,
     b'1: result/1
  ESAC.

MAC CARRY = (t_add:in) -> STRING[1]bit: CASE in
  OF add: b'0",
     sub: b'1"
  ESAC.

MAC BOOL_BIT = (bool:in) -> STRING[1] bit:
CASE in
  OF t: b'1"

```

```

ELSE b"0"
ESAC.

MAC BOOL_STRING(INT n) = ((n)bool:in) ->STRING[n] bit:
(LET out = BOOL_BIT 'in[1].
OUTPUT IF n=1
  THEN out
  ELSE out[1] CONC BOOL_STRING(n-1){(n[2..n])
  FI
).

MAC BIT_STRING(INT n) = ((n)bit:in) ->STRING[n] bit:
(LET out = B_TO_S in[1].
OUTPUT IF n=1
  THEN out
  ELSE out[1] CONC BIT_STRING(n-1){(n[2..n])
  FI
).

MAC ZERO(INT n) = (STRING[1]bit:dummy) ->STRING[n]bit:
IF n=1 THEN b"0"
ELSE b"0" CONC ZERO(n-1) b"0"
FI.

MAC ALL_SAME(INT n) = (STRING[1]bit:dummy) ->STRING[n]bit:
IF n=1 THEN dummy
ELSE dummy CONC ALL_SAME(n-1) dummy
FI.

```

**COM**

The operators described in this section are optimal and take two-valued operands and produce a two-valued result. They may not be used with ELLA-integers or associated types.

The first basic value of any two-valued type declaration of the operand(s) and the result are interpreted by the operations as false, and the second basic value is interpreted as true. Thus, given the following type declarations:

**MOC**

**MAC AND\_T = (TYPE t: a b) -> t: BIOP AND.**

**MAC OR\_T = (TYPE t: a b) -> t: BIOP OR.**

**MAC XOR\_T = (TYPE t: a b) -> t: BIOP XOR.**

**MAC NOT\_T = (TYPE t: a) -> t: BIOP NOT.**

**COM**

The following operations take bit-string operand(s) and are bitwise, ie the operation is performed on the operand(s) one bit at a time. The operand(s) and result must all be ELLA-strings of the same length.

**MOC**

**MAC AND\_B = (STRING[INT n]bit, STRING[n]bit) -> STRING[n]bit:  
BIOP AND.**

**MAC OR\_B = (STRING[INT n]bit, STRING[n]bit) -> STRING[n]bit:  
BIOP OR.**

MAC XOR\_B = (STRING[INT n]bit, STRING[n]bit) -> STRING[n]bit:  
BIOP XOR.

MAC NOT\_B = (STRING[INT n]bit) -> STRING[n]bit:  
BIOP NOT.

COM

The operators described in this section may be used with primitive types ie all enumerated types, except associated types, rows, strings and structures. These operations take two operands which must be of the same type and the result can be any two-valued type; we have packaged these BIOPs so they output a value of type 'bool' - you may change this if you wish.

MOC

MAC EQ = (TYPE t: a b) -> bool: BIOP EQ.

MAC GT = (TYPE t: a b) -> bool: BIOP GT.

MAC GE = (TYPE t: a b) -> bool: BIOP GE.

MAC LT = (TYPE t: a b) -> bool: BIOP LT.

MAC LE = (TYPE t: a b) -> bool: BIOP LE.

COM

NOTE: these BIOPs are designed to take any primitive ELLA type. Since it is not possible to distinguish between primitive and other types, whilst leaving the macro declaration general enough to allow the use of all two-valued types that might be declared, there are type-checking limitations. This is done at network assembly, so use of illegal types will not generate an error

message until then.

NB: ARITH provides for relational operations on ELLA-integer types.  
MOC

COM

These operations are optimal in their handling of '?' and operate on bit-string representations of unsigned integers. The result may be any two-valued type; we have used type 'bool'. The inputs can be of different lengths and different types.

MOC

MAC EQ\_U = (STRING[INT n]bit, STRING[INT m]bit) -> bool:  
BIOP EQ\_US.

MAC GT\_U = (STRING[INT n]bit, STRING[INT m]bit) -> bool:  
BIOP GT\_US.

MAC GE\_U = (STRING[INT n]bit, STRING[INT m]bit) -> bool:  
BIOP GE\_US.

MAC LT\_U = (STRING[INT n]bit, STRING[INT m]bit) -> bool:  
BIOP LT\_US.

MAC LE\_U = (STRING[INT n]bit, STRING[INT m]bit) -> bool:  
BIOP LE\_US.

# Bit-strings representing signed numbers #

COM

These operations are optimal and operate on bit-string representations of signed integers. The result may be any two-valued type; we have used type

'bool'. The inputs can be of different lengths and different types.  
MOC

MAC EQ \_S = (STRING[INT n]bit, STRING[INT m]bit) -> bool:  
BIOP EQ \_S.

MAC GT \_S = (STRING[INT n]bit, STRING[INT m]bit) -> bool:  
BIOP GT \_S.

MAC GE \_S = (STRING[INT n]bit, STRING[INT m]bit) -> bool:  
BIOP GE \_S.

MAC LT \_S = (STRING[INT n]bit, STRING[INT m]bit) -> bool:  
BIOP LT \_S.

MAC LE \_S = (STRING[INT n]bit, STRING[INT m]bit) -> bool:  
BIOP LE \_S.

# Shift operations #  
COM

These operate on bit-strings. Both the enclosing macro and the BIOP are parameterised by the number of bits to be shifted (INT p). The macro and BIOP parameters must match. Note that no bits are lost in these shift operations, so you may need to trim the result to achieve the desired effect.

SR means shift right; SL means shift left.

The macros with the suffix '\_S' perform arithmetic shifts; those with the

suffix 'U' perform bool shifts.  
MOC

MAC SL\_S(INT p) = (STRING[INT n]bit) -> STRING[n + p]bit:  
BIOP SL(p).

MAC SL\_U(INT p) = (STRING[INT n]bit) -> STRING[n + p]bit:  
BIOP SL(p).

MAC SR\_S(INT p) = (STRING[INT n]bit) -> STRING[n + p]bit:  
BIOP SR\_S(p).

MAC SR\_U(INT p) = (STRING[INT n]bit) -> STRING[n + p]bit:  
BIOP SR\_US(p).

# Arithmetic operations #

# Bit-strings representing unsigned numbers #

# addition. #

MAC ADD\_U = (STRING[INT m]bit, STRING[INT n]bit)  
-> STRING[IF m >= n THEN m+1 ELSE n+1 F]bit:  
BIOP PLUS\_US.

# subtraction on bit-string representations of unsigned integers. Output is #  
# signed. #

MAC SUB\_U = (STRING[INT m]bit, STRING[INT n]bit)  
-> STRING[IF m >= n THEN m+1 ELSE n+1 F]bit:

BIOP MINUS\_US.

# negation. Output is signed. #

MAC NEG\_U = (STRING[INT n]bit) -> STRING[n+1]bit:  
BIOP NEGATE\_US.

# multiplication. #

MAC MULT\_U = (STRING[INT m]bit, STRING[INT n]bit) -> STRING[m+n]bit:  
BIOP TIMES\_US.

COM

-divide. If the divisor is non-zero then the first element of the output is 'ok' and the second and third elements are the quotient and remainder; otherwise, the first element is 'error' and the rest is set to '?'.  
MOC

MAC DIV\_U = (STRING[INT m]bit, STRING[INT n]bit)  
-> (flag, STRING[m]bit, STRING[n]bit):

BIOP DIVIDE\_US.

# square root. #

MAC SQRT\_U = (STRING[INT n]bit) -> STRING[(n+1) % 2]bit:  
BIOP SQRT\_US.

COM

modulus (result always positive). If the divisor is non-zero, then the first element of the output is 'ok' and the second element is the modulus; otherwise, the first element is 'error' and the second is '?'.  
MOC



MOC

MAC MOD\_U = (STRING[INT m]bit,STRING[INT n]bit)  
-> (flag,STRING[n]bit):  
BIOP MOD\_US.

COM

- convert between one range of bit-string and another. If the input value cannot be represented as a legal value for the output string, the result is 'error' and '?'.  
MOC

MAC RANGE\_U {INT m} = (STRING[INT n]bit)  
-> (flag,STRING[m]bit):  
BIOP RANGE\_US.

# Bit-strings representing signed numbers #

# addition. #

MAC ADD\_S = (STRING[INT m]bit,STRING[INT n]bit)  
-> STRING[(IF m >= n THEN m+1 ELSE n+1 F]bit:  
BIOP PLUS\_S.

# subtraction. #

MAC SUB\_S = (STRING[INT m]bit,STRING[INT n]bit)  
-> STRING[(IF m >= n THEN m+1 ELSE n+1 F]bit:  
BIOP MINUS\_S.

# negation. #

MAC NEG\_S = (STRING[INT n]bit) -> STRING[n+1]bit:  
 BIOP NEGATE\_S.

# multiplication. #

MAC MULT\_S = (STRING[INT m]bit, STRING[INT n]bit) -> STRING[m+n]bit:  
 BIOP TIMES\_S.

COM

divide. If the divisor is non-zero then the first element of the output is 'ok' and the second and third elements are the quotient and remainder; otherwise, the first element is 'error' and the rest is set to '?'. The remainder has the same sign as the divisor.

MOC

MAC DIV\_S = (STRING[INT m]bit, STRING[INT n]bit)  
 -> (flag, STRING[m]bit, STRING[n]bit):  
 BIOP DIVIDE\_S.

COM

modulus (result always positive). If the divisor is non-zero, then the first element of the output is 'ok' and the second element is the unsigned modulus; otherwise, the first element is 'error' and the second is '?'.  
 MOC

MAC MOD\_S = (STRING[INT m]bit, STRING[INT n]bit)  
 -> (flag, STRING[n]bit):  
 BIOP MOD\_S.

COM

- convert between one range of bit-string and another. If the input value cannot be represented as a legal value for the output string, the result is 'error' and '?'.  
MOC

MAC RANGE\_S {INT m} = (STRING[INT n]bit)

-> (flag, STRING[m]bit):

BIOP RANGE\_S.

# absolute value. The output represents an unsigned Integer. #

MAC ABS\_S = (STRING[INT n]bit) -> STRING[n]bit:

BIOP ABS\_S.

# Built in Register #

MAC DREG{INT interval delay} = (TYPE t) -> t:

ALIEN REGISTER {interval, ?t, 0, delay}.

MAC GEN\_DREG{INT interval, CONST (TYPE t): Init, INT skew delay} = (t) -> t:

ALIEN REGISTER {interval, init, skew, delay}.

# Built in type conversion #

MAC CAST{TYPE t} = (TYPE s) -> t:

ALIEN CAST.

```

MAC ALL_SAME{INT n} = (STRING[1]bit:dummy) ->STRING[n]bit:
BEGIN
  FAULT IF n < 1 THEN "N<1 in ALL_SAME" FI.
  OUTPUT IF n=1 THEN dummy
  ELSE dummy CONC ALL_SAME{n-1} dummy
  FI
END.

MAC CAST {TYPE to} = (TYPE from:in) ->to:ALIEN CAST.

MAC ZERO{INT n} = (STRING[1]bit:dummy) ->STRING[n]bit:
BEGIN
  FAULT IF n < 1 THEN "N<1 in ZERO" FI.
  OUTPUT IF n=1 THEN b"0"
  ELSE b"0" CONC ZERO{n-1} b"0"
  FI
END.

MAC B_TO_S= (bit:in) ->STRING[1]bit: CASE in
  OF b"0:b"0",
    b"1:b"1"
  ESAC.

MAC S_TO_IN = (STRING[input_exp]bit:in) -> (flag,t_input): BIOP TRANSFORM_S.
MAC IN_TO_S{INT n} = (t_input: in) -> (flag,STRING[n]bit): BIOP TRANSFORM_S.

MAC S_HUFF = (STRING[6]bit) -> (flag,t_huffman): BIOP TRANSFORM_US.
MAC HUFF_S = (t_huffman) -> (flag,STRING[6]bit): BIOP TRANSFORM_US.

MAC BOOL_BIT = (bool:in) ->STRING[1] bit:

```

```

CASE in
OF t:b'1"
ELSE b'0"
ESAC.
MAC BIT_BOOL = (bit:in)    -> bool:
CASE in
OF b'1:t
ELSE f
ESAC.

MAC BOOL_STRING(INT n) = ((n)bool:in) -> STRING[n] bit:
(LET out = BOOL_BIT in{1}.
OUTPUT IF n=1
THEN out
ELSE out{1} CONC BOOL_STRING(n-1){(n[2..n])}
FI
).
# defines the types used for the 2D wavelet chip#

#constant values#
INT  result_exp=14,    #length of result arith#
      input_exp=10,    #length of 1D convolver input/output#
      qmax = 7,        #maximum shift value for quantisation constant#
      result_range = 1 SL (result_exp-1),
      input_range = 1 SL (input_exp-1),
      max_octave=3, #no of octaves=max_octave + 1, can not be less in this example#
      no_octave=max_octave+1,  ##
      xsize = 10,  #no of bits for ximage#
      ysize = 9,  #no of bits for yimage#
      ximage=319, #the xdimension -1 of the image, ie no of cols#

```

yimage=239 #the ydimension -1 of the image, ie no of rows#

```
#int types#
TYPE t_result= NEW result/( -(result_range)..(result_range-1)),
t_input= NEW input/( -(input_range)..(input_range-1)),
t_length= NEW len/(0..15),
t_inp = NEW inp/(0..1023),
t_blk =NEW blk/(0..3),
t_sub =NEW sub/(0..3),
t_col =NEW col/(0..ximage),
t_row =NEW row/(0..yimage),
t_carry =NEW carry/(0..1),
t_quant =NEW quant/(0..qmax),
#address for result&dwt memory, ie 1 frame#
t_sparc_addr =NEW addr/(0..(1 SL max_octave)*( ximage+1)*(yimage+1)-(ximage+1)-1),
t_octave=NEW oct/(0..(max_octave+1)),
```

#bit string and boolean types#

```
bit = NEW b('0' | '1'),
bool = NEW (fl),
flag = NEW(error | ok),
```

#control signals#

```
t_reset = NEW(rst|no rst),
t_load = NEW(write|read), #r/wbar control#
t_cs = NEW(no_select|select), #chip select control#
t_updown= NEW(down|up), #up/down counter control#
t_diff= NEW(diff|nodiff), #diff or not in quantiser#
t_intra = NEW(intra|inter),
```

```

#convolver mux & and types#
t_mux = NEW(left|right),
t_mux3 = NEW(l|c|r),
t_mux4 = NEW(unol|dos|tres|quatro),
t_add = NEW(add|subit),
t_direction=NEW(forward|inverse),

#counter types#
t_count_control=NEW(count_rst|count_carry),
t_count_2 = NEW(one|two),

#state types#
t_token = NEW (t_0|t_1|t_11|t_100|t_101),
t_mode= NEW(void|void_still|stop|send|still|still_send|lpf_send|lpf_still|lpf_stop),
t_cycle = NEW(token_cycle|data_cycle|skip_cycle),
t_state= NEW(start|up0|up1|zz0|zz1|zz2|zz3|down1),
t_decode = NEW(load_low|load_high),
t_high_low = NEW(low|high),
t_huffman = NEW(pass|huffman),
t_fifo = NEW(ok_fifo|error_fifo),
#types for the octave control unit#
t_channel= NEW(y|u|v),
t_channel_factor= NEW(luminance|color),
#types for the control of memory ports#
t_sparcport=(t_sparc_addr#wr_addr#,t_sparc_addr#rd_addr#,t_load#wr#t_cs#cs#)

#generate random values for test memories#

FN GEN_RANDOM_MEM = (bool:ck,t_reset:reset) ->t_input: BOOL_INT10 PRBS11(ck,reset).
TYPE t_test = NEW(no|yes).
#.....#
#These functions change types from boolean to inpu te ger and vice-#

```

```

#versa. Supports 1 & 8 bit booleans.      #
#.....#

FN INT_BOOL1=(t_input:k) ->bool:      # 1bit input to binary #
CASE k
OF input/0:f,
   input/1:1
ESAC.

FN BOOL_INT=(bool:b) ->t_input:      # 1 bit bool to input #
CASE b
OF f:input/0,
   t:input/1
ESAC.

FN * =(t_input:a b) ->t_input: ARITH a*b.
FN % =(t_input:a b) ->t_input: ARITH a%b.
FN - =(t_input:a b) ->t_input: ARITH a-b.
FN + =(t_input:a b) ->t_input: ARITH a+b.
FN = =(t_input:a b) ->t_test: ARITH IF a=b THEN 2 ELSE 1 FI.

COM
FN CHANGE_SIGN = (t_input:i) ->t_input: #changes sign for 8-bit 2's#
ARITH IF i<0 THEN 128+i      #complement no, #
ELSE i
FI.

FN SIGN = (t_input:i) ->bool:      #gets sign for 2's#
ARITH IF i<0 THEN 1      #complement nos #
ELSE 2

```



FI.

```

FN TEST_SIZE = (t_input:x) -> bool:
#tests to see if the input is bigger than an 8-bit integer#
  ARITH IF ( (x<=-128) AND (x>127)) THEN 1
    ELSE 2  FI.

```

```

FN INT8_BOOL=(t_input:orig) ->[8]bool:
BEGIN

```

```

  SEQ
    VAR i1:=input/0, #input variables#
    i0:=CHANGE_SIGN(orig),
    b:=(f,f,f,f,f,SIGN(orig));
    [INT n=1..7] (
      i1:=i0%input/2;
      b[n]:=INT_BOOL1(i0-input/2*i1);
      i0:=i1
    );
    OUTPUT CASE TEST_SIZE orig #checks to see if orig will#
      OF: [8]?bool, #fit input to an 8_bit value#
         f: b
         ESAC
    END.

```

```

FN BOOL_INT8=([8]bool:b) ->t_input: #converts 8bit boolean to 2's#
BEGIN
  SEQ #complement integer #
    VAR sum:=input/-128 * BOOL_INT(b[8]),
    exp:=input/1;

```

```

[INT k=1..7]
( sum:=sum+exp*BOOL_INT(b[k]);
  exp:=input/2 * exp
);
OUTPUT sum
END.

MOC
FN BOOL_INT10=(t[10]bool:b) ->t_input: #converts 10bit boolean to 2's#
BEGIN
  SEQ      #complement integer #
  VAR sum:=input/-512 * BOOL_INT(b[10]),
      exp:=input/1;
  [INT k=1..9]
  ( sum:=sum+exp*BOOL_INT(b[k]);
    exp:=input/2 * exp
  );
  OUTPUT sum
END.
COM
FN BOOL_INT16=(t[8]bool:in1 in2) ->t_input:
# converts a 16-bit no., (lsbs,msbs) input to integer form)#
(BOOL_INT8(in1))+((input/256)*BOOL_INT8(in2))+((input/256)*BOOL_INT(in1[8])).
#hack because of sign extend#
#of lsb #
MOC
COM
FN PRBS10 = (t_reset:reset) ->[10]bool:
#A 10 bit prbs generator, feedback taps on regs 3 & 10.#
BEGIN

```

```

MAKE[10]MYLATCH:l,
XNOR:xnor.

FOR INT k=1..9 JOIN
(reset,[k]) ->[k+1].

JOIN (reset,xnor) ->[1],
([10],[3]) ->xnor.

OUTPUT l
END.
MOC
FN PRBS11 = (bool:ck,t,reset:reset) ->[10]bool:
#A 11 bit prbs generator,feedback taps on regs 2 & 11.#
BEGIN
MAKE[11]DFF(bool):l,
XOR:xor.

FOR INT k=1..10 JOIN
(ck,reset,[k],f) ->[k+1].

JOIN (ck,reset,NOTxor,f) ->[1],
([11],[2]) ->xor.

OUTPUT [1..10]
END.
COM
FN PRBS16 = (bool:reset)->[16]bool:
#A 16 bit prbs generator,feedback taps on regs 1,3,12,16#
BEGIN
MAKE[16]MYLATCH:l,

```

```
XOR_4:xor,
NOT:xnor.
```

```
FOR INT k=1..15 JOIN
  (ck,reset,[k])->[k+1].
```

```
JOIN (ck,reset,xnor) ->[1],
      ([1],[3],[16],[12]) ->xor,
xor ->xnor.
```

```
OUTPUT ([INT k=1..16][k])
```

```
END.
```

```
FN PRBS12 = (clock:ck,bool:reset) ->[12]bool:
```

```
#A 12 bit prbs generator,feedback taps on regs 1,4,6,12.#
```

```
BEGIN
```

```
  MAKE[12]MYLATCH:l,
```

```
  XOR_4:xor,
```

```
  NOT:xnor.
```

```
FOR INT k=1..11 JOIN
  (ck,reset,[k])->[k+1].
```

```
JOIN (ck,reset,xnor) ->[1],
      ([1],[4],[6],[12]) ->xor,
xor ->xnor.
```

```
OUTPUT ([INT k=1..12][k])
```

```
END.
```

```
FN PRBS8 = (clock:ck,bool:reset) ->[8]bool:
```

```
#A 8 bit prbs generator,feedback taps on regs 2,3,4,8.#
```

```
BEGIN
```

```
  MAKE[8]MYLATCH:l,
```

```

XOR_4:xor,
NOT:xnor.

FOR INT k=1..7 JOIN
  (ck,reset,[k])->[k+1].

  JOIN (ck,reset,xnor) ->[1],
        ([2],[3],[4],[8]) ->xor,
        xor ->xnor.
  OUTPUT ([INT k=1..8][k])
  END.
MOC
#test for palmas chip#
TYPE t_int32 = NEW int32/(-2147483000..2147483000).

FN RMS = (bool:ck,t_reset:reset,t_cycle:cycle, t_input:old new) ->t_int32:
BEGIN

  FN I_32 = (t_input:in) ->t_int32:ARITH in.
  FN DV = (t_int32:a b) ->t_int32:ARITH a%b.
  FN PL = (t_int32:a b) ->t_int32:ARITH a+b.
  FN MI = (t_int32:a b) ->t_int32:ARITH a-b.
  FN TI = (t_int32:a b) ->t_int32:ARITH a*b.

  MAKEOFF_INIT(t_int32:old_error.

  LET err = I_32old MI I_32new,
        err2 = (err1err) PL old_error.

  JOIN (ck,reset,CASE cycle
        OFdata_cycle:write

```

```

ELSE read
  ESAC,err2,int32/0) -->old_error.

OUTPUT old_error
END.

FN EQ = (t_input:a b) ->bool:ARITH IF a=b THEN 2
      ELSE 1
      FI.

FN SPARC_MEM = (t_input:in,t_sparc_addr:wr_addr,t_sparc_addr:rd_addr,t_load:rw_sparc#,t_cs:cs#)->t_input:
RAM(input/0).

FN FIFO = (bool:ok,t_reset:reset,STRING[16]bit:buffer_in,t_direction:direction,t_load:fifo_read_fifo_write)
-->(STRING[16]bit,[2]t_fifo): #fifo_full,empty#
BEGIN
  FN FIFO_RAM = (STRING[16]bit:in,t_inp:wr_addr rd_addr,t_load:rw_fifo) ->STRING[16]bit:
RAM(b"0000000000000000").
  FN FULL = (t_inp:in) ->t_fifo:ARITH IF in>1023 THEN 2 #fifo_full#
      ELSE 1
      FI.
  FN INCR = (t_inp:in) ->t_inp:ARITH in+1.

  FN EMPTY = (t_inp:in) ->t_fifo:ARITH IF in<0 THEN 2 #fifo_empty#
      ELSE 1
      FI.
  FN DECR = (t_inp:in) ->t_inp:ARITH in-1.

  MAKEDFF(t_inp):address,

```

```

FIFO_RAM:ram.

LET  next = CASE direction
    OF forward: CASE fifo_write
        OF write: INCR address
        ELSE address
        ESAC,
        inverse: CASE fifo_read
        OF read: INCR address
        ELSE address
        ESAC
    ESAC.

JOIN (ck, reset, next, inp/0) -> address,
    (buffer_in , address, address, CASE direction
    OF inverse: read,
        forward: fifo_write
        ESAC) -> ram.

OUTPUT  (ram, (FULL address, EMPTY address))
END.

FN TEST_PALMAS = (bool: ck, t_reset: reset, t_direction: direction, t_intra: intra_inter, t_channel_factor: channel_factor,
    t_input: q_int, t_quant: quant_norm, t_result: threshold comparison)
-> (STRING[16] bit, #buffer_out#[2] t_load#fifo_read fifo_write#, bool, bool, t_int32):

BEGIN

```

```

MAKE SPARC_MEM:new old_inv old_forw,
FIFO:ffifo,
PALMAS:palmas_inv palmas_forw.

LET  col_length = (IN_TO_S(9) input/31)[2],
      row_length = (IN_TO_S(9) input/31)[2],
      ximage_string = (IN_TO_S(9) input/32)[2],
      yimage_string = (IN_TO_S(9) input/32)[2],
      yimage_string_3 = (IN_TO_S(9) input/80)[2],
      pro_forw = palmas_forw[1],
      pro_inv = palmas_inv[1],
      forw_frame_done = palmas_forw[7],
      inv_frame_done = palmas_inv[7],
      cycle = palmas_inv[8],
      old_equal = CASE cycle
                    OF data_cycle:old_forw EQ palmas_inv[1]
                    ELSE 1
                    ESAC.

```

JOIN



```

#tx fifo full/empty logic later#
(ck,reset,forward,intra_inter,channel_factor,q_int,quant_norm,b"0000000000000000",new_old_forw,threshold,comparison,
 #fifo[2][1],fifo[2][2]#ok_fifo,col_length,row_length,ximage_string,yimage_string,yimage_string_3)
    ->palmas_forw,

(ck,reset,inverse,intra_inter,channel_factor,q_int,quant_norm,fifo[1],new_old_inv,threshold,comparison,
 #fifo[2][1],fifo[2][2]#ok_fifo,col_length,row_length,ximage_string,yimage_string,yimage_string_3)
    ->palmas_inv,

#old forward mem, on forward use as normal, on inverse read values to compare with inverse#
(pro_forw,CASE direction
  OF forward:palmas_forw[2],
    inverse:palmas_inv[2]
  ESAC, CASE direction
  OF forward:palmas_forw[2],
    inverse:palmas_inv[2]
  ESAC,CASE direction
    OF forward:palmas_forw[4][1],
      inverse:read
    ESAC)    ->old_forw,

(palmas_inv[1],palmas_inv[2],palmas_inv[2],CASE direction
  OF forward:read,
    inverse:palmas_inv[4][1]
  ESAC)    ->old_inv,

#(input/0,palmas_forw[2],palmas_forw[2],palmas_forw[3][1])    ->new,#
(input/0,CASE direction
  OF forward:palmas_forw[2],
    inverse:palmas_inv[2]
  ESAC, CASE direction

```

```

OF forward:palmas_forw[2],
   inverse:palmas_inv[2]
ESAC,CASE direction
  OF forward:palmas_forw[3][1],
     inverse:read
   ESAC)
      ->new,

(ck,reset,CASE direction
  OF inverse:b'0000000000000000',
     forward:palmas_forw[5]
   ESAC
     ,direction,palmas_inv[6][1],palmas_forw[6][2]) ->ffo.

OUTPUT (palmas_forw[5],palmas_forw[6],palmas_forw[7],old_equal,RMS(ck,reset,cycle,old_inv,new) )
END.

#test for palmas chip#
TYPE t_int32 = NEW int32/(-2147483000..2147483000).

FN RMS = (bool:ck,t_reset:reset,t_cycle:cycle, t_input:old new) ->t_int32:
BEGIN

FN I_32 = (t_input:in) ->t_int32:ARITH in.
FN DV = (t_int32:a b) ->t_int32:ARITH a%b.
FN PL = (t_int32:a b) ->t_int32:ARITH a+b.
FN MI = (t_int32:a b) ->t_int32:ARITH a-b.
FN TI = (t_int32:a b) ->t_int32:ARITH a*b.

MAKE OFF_INIT(t_int32:old_error.
LET err = I_32old MI I_32new,
    err2 = (errTIerr) PL old_error.

```

```

JOIN  (ck,reset,CASE cycle
      OF  data_cycle:write
      ELSE read
      ESAC,err2,int32(0)      ->old_error.

OUTPUT old_error
END.
FN EQ = (t_input:a b) ->bool:ARITH IF a=b THEN 2
      ELSE 1
      FI.

FN SPARC_MEM = (t_input:in,t_sparc_addr:wr_addr,t_sparc_addr:rd_addr,t_load:rw_sparc#,t_cs:cs#)->t_input:
RAM(input/0).

FN FIFO_BIG   =(bool:ck,t_reset:reset,STRING[16]bit:buffer_in,t_direction:direction,t_load:ffifo_read_ffifo_write)
              ->(STRING[16]bit,[2]t_ffifo):  #ffifo_full,empty#

BEGIN
  FN FIFO_RAM = (STRING[16]bit:in,t_sparc_addr:wr_addr rd_addr,t_load:rw_ffifo) ->STRING[16]bit:
RAM(b"000000000000000000").

  FN FULL = (t_sparc_addr:in) ->t_ffifo:ARITH IF in>1023 THEN 2  #ffifo full#
          ELSE 1
          FI.

  FN INCR = (t_sparc_addr:in) ->t_sparc_addr:ARITH in+1.

  FN EMPTY = (t_sparc_addr:in) ->t_ffifo:ARITH IF in<0 THEN 2 #ffifo empty#
          ELSE 1
          FI.

  FN DECR = (t_sparc_addr:in) ->t_sparc_addr:ARITH in-1.

```

```

MAKE DFF(t_sparc_addr):address,
    FIFO_RAM:ram.
LET next = CASE direction
    OF forward: CASE fifo_write
        OF write:NCR address
            ELSE address
                ESAC,
            inverse:CASE fifo_read
                OF read:NCR address
                    ELSE address
                        ESAC
        ESAC.

```

```

JOIN (ck,reset,next,addr/0) -->address,
    (buffer_in,address,address,CASE direction
        OF inverse:read,
            forward:fifo_write
                ESAC) -->ram.

```

```

OUTPUT (ram,(FULL address,EMPTY address))
END.

```

```

FN TEST_PALMAS = (bool:ck,t_reset:reset, bool:load_memory,t_direction:direction,t_intra:intra_inter,
    t_channel_factor:channel_factor,{4}t_quant:quant_norm,{4}t_result:threshold,
    t_input: col_length_in row_length_in ximage_string_in yimage_string_in,
    t_result:yimage_string_3_in)
-->(bool#t_int32#):

```

```

BEGIN
  FN NEW_ADDRESS = (t_sparc_addr:in)      -> t_sparc_addr: ARITH ((in +1) MOD 120000).

  MAKE SPARC_MEM: new old_inv old_forw,
    FIFO_BIG: ffo,
    PRBS11: prbs,
    DFF{t_sparc_addr}: address,
    PALMAS: palmas.

  LET
    col_length = (IN_TO_S(10) col_length_in)[2],
    row_length = (IN_TO_S(9) row_length_in)[2],
    ximage_string = (IN_TO_S(10) ximage_string_in)[2],
    yimage_string = (IN_TO_S(9) yimage_string_in)[2],
    yimage_string_3 = (I_TO_SC(1) yimage_string_3_in)[2],

    pro = palmas[1],

    random_data = BOOL_INT10 prbs,

    frame_done = palmas[7],

    cycle = palmas[8],

    old_equal = CASE cycle

```

```

OF data_cycle:old_forw EQ palmas[1]
ELSE t
ESAC.

JOIN
#fix fifo full/empty logic later#
(ck,reset,direction,intra_inter,channel_factor,quant_norm,CASE direction
OF forward:b"0000000000000000"
ELSE fifo[1]
ESAC,new,CASE direction
OF forward:old_forw
ELSE old_inv
ESAC,threshold,
#fifo[2][1],fifo[2][2]#ok_fifo,ok_fifo,col_length,row_length,ximage_string,yimage_string_3)
(ck,reset,(NEW_ADDRESS address),addr/0) --> address,
(ck,reset) --> prbs,

#old forward mem, on forward use as normal, on inverse read values to compare with inverse#
(CASE load_memory
OF t:DIFF(t_input)(ck,reset,random_data,input/0)
ELSE palmas[1]
ESAC , CASE load_memory
OF t:address
ELSE palmas[2]
ESAC, palmas[2], CASE load_memory
OF t:write
ELSE CASE direction
OF forward:palmas[4][1],

```

```

        inverse:read
        ESAC
    ESAC)
        ->old_forw,

(CASE load_memory
OF t:DFf{t_input}{ck,reset,random_data,input/0)
ELSE palmas[1]
ESAC , CASE load_memory
OF t:address
ELSE palmas[2]
ESAC, palmas[2], CASE load_memory
OF t:write
ELSE CASE direction
OF forward:read,
inverse:palmas[4][1]
ESAC
ESAC)
        ->old_inv,

(CASE load_memory
OF t:random_data
ELSE input/0
ESAC , CASE load_memory
OF t:address
ELSE palmas[2]
ESAC, palmas[2], CASE load_memory
OF t:write
ELSE CASE direction
OF forward:palmas[3][1],
inverse:read
ESAC
ESAC)
        ->new,

```

```

(ck,reset,CASE direction
  OF inverse:"0000000000000000",
    forward:palmas[5]
  ESAC    ,direction,palmas[6][1],palmas[6][2]) ->fifo.

OUTPUT (old_equal#,RMS(ck,reset,cycle,old_inv,new)#)
END.

#test for palmas chip#
TYPE t_int32 = NEW int32/(-2147483000..2147483000).

FN RMS = (bool:ck,t_reset:reset,t_cycle:cycle,t_input:old new) ->t_int32:
BEGIN

  FN l_32 = (t_input:in) ->t_int32:ARITH in.
  FN DV = (t_int32:a b) ->t_int32:ARITH a%b.
  FN PL = (t_int32:a b) ->t_int32:ARITH a+b.
  FN MI = (t_int32:a b) ->t_int32:ARITH a-b.
  FN TI = (t_int32:a b) ->t_int32:ARITH a*b.

  MAKEDFF_INIT(t_int32):old_error.

  LET err = l_32old MI l_32new,
    err2 = (errTIerr) PL old_error.

  JOIN (ck,reset,CASE cycle
    OF data_cycle:write
    ELSE read
    ESAC,err2,int32/0) ->old_error.

```



```

OUTPUT old_error
END.

FN EQ = (t_input:a b) ->bool:ARITH IF a=b THEN 2
      ELSE 1
      FI.

FN SPARC_MEM = (t_input:in,t_sparc_addr:wr_addr,t_sparc_addr:rd_addr,t_load:rw_sparc#t_cs:cs#)->t_input:
RAM(input/0).

FN FIFO      =(bool:ck,t_reset:reset,STRING[16]bit:buffer_in,t_direction:direction,t_load:fifo_read fifo_write)
->(STRING[16]bit,[2]t_fifo): #fifo_full,empty#

BEGIN
  FN FIFO_RAM = (STRING[16]bit:in,t_inp:wr_addr rd_addr,t_load:rw_fifo) ->STRING[16]bit:
RAM(b"0000000000000000").

  FN FULL = (t_inp:in) ->t_fifo:ARITH IF in>1023 THEN 2 #fifo_full#
      ELSE 1
      FI.

  FN INCR = (t_inp:in) ->t_inp:ARITH in+1.

  FN EMPTY = (t_inp:in) ->t_fifo:ARITH IF in<0 THEN 2 #fifo_empty#
      ELSE 1
      FI.

  FN DECR = (t_inp:in) ->t_inp:ARITH in-1.

MAKEDFF(t_inp:address,
FIFO_RAM:ram.

```

```

LET  next = CASE direction
OF forward: CASE fifo_write
  OF write: INCR address
  ELSE address
  ESAC,
  inverse: CASE fifo_read
  OF read: INCR address
  ELSE address
  ESAC.
ESAC.

JOIN  (ck, reset, next, inp/0) -> address,
      (buffer_in, address, address, CASE direction
      OF inverse: read,
      forward: fifo_write
      ESAC) -> ram.

OUTPUT  (ram, (FULL address, EMPTY address))
END.

FN TEST_PALMAS = (bool: ck, t_reset: reset, bool: load_memory, t_direction: direction, t_intra: intra_inter, t_channel_factor: channel_factor,
t_input: q_int, t_quant: quant_norm, t_result: threshold comparison)
-> (bool, t_int32):

BEGIN

FN NEW_ADDRESS = (t_sparc_addr: in) -> t_sparc_addr: ARITH ((in + 1) MOD 120000).

```

- 640 -

```

MAKE SPARC_MEM:new old_inv old_forw,
FIFO:fifo,
PRBS11:prbs,
DFF{t_sparc_addr}:address,
PALMAS:palmas.

LET   col_length = (IN_TO_S{10} input/31)[2],
      row_length = (IN_TO_S{9} input/31)[2],
      ximage_string = (IN_TO_S{10} input/32)[2],
      yimage_string = (IN_TO_S{9} input/32)[2],
      yimage_string_3 = (! TO_SC{11} result/80)[2],
      pro = palmas[1],
      random_data = BOOL_INT10 prbs,
      frame_done = palmas[7],
      cycle = palmas[8],
      old_equal = CASE cycle
                    OF data_cycle:old_forw EQ palmas[1]
                    ELSE 1
                    ESAC.

```

```

JOIN
#fix fifo full/empty logic later#
(ck,reset,direction,intra_inter,channel_factor,q_int,quant_norm,fifo[1],new,CASE direction
  OF forward:old_forw
  ELSE old_inv
  ESAC, threshold,comparison,
#fifo[2][1],fifo[2][2]#ok_fifo,ok_fifo,col_length,row_length,ximage_string,yimage_string,yimage_string_3)
->palmas,

(ck,reset,(NEW_ADDRESS address),addr(0))      -> address,

(ck,reset)      ->prbs,

#old forward mem, on forward use as normal, on inverse read values to compare with inverse#
(CASE load_memory
  OF t:FFF{t_input}{ck,reset,random_data,input(0)}
  ELSE palmas[1]
  ESAC, CASE load_memory
  OF t:address
  ELSE palmas[2]
  ESAC, palmas[2], CASE load_memory
  OF t:write
  ELSE CASE direction
  OF forward:palmas[4][1],
  inverse:read
  ESAC
  ESAC)      ->old_forw,

(CASE load_memory
  OF t:FFF{t_input}{ck,reset,random_data,input(0)}
  ELSE palmas[1]

```

```

ESAC , CASE load_memory
  OF t:address
    ELSE palmas[2]
      ESAC, palmas[2], CASE load_memory
        OF t:write
          ELSE CASE direction
            OF forward:palmas[4][1],
              inverse:read
                ESAC
                  ESAC)
                    ->old_inv,

(CASE load_memory
  OF t:random_data
    ELSE input/0
      ESAC , CASE load_memory
        OF t:address
          ELSE palmas[2]
            ESAC, palmas[2], CASE load_memory
              OF t:write
                ELSE CASE direction
                  OF forward:palmas[3][1],
                    inverse:read
                      ESAC
                        ESAC)
                          ->new,

(ck,reset,CASE direction
  OF inverse:b"0000000000000000",
    forward:palmas[5]

```

```
ESAC      ,direction,palmas[6][1],palmas[6][2])  ->fifo.  
OUTPUT (old_equal,RMS(ck,reset,cycle,old_inv,new) )  
END.
```

APPENDIX C

7/24/93 3:39 PM

Engineering:KlicsCode:CompPict:Top.a

```

*-----
*
*  © Copyright 1993 KLIICS Limited
*  All rights reserved.
*
*  Written by: Adrian Lewis
*
*-----

```

```

*
*  680X0 Fast Top Octave
*
*-----

```

```

*
*      seg      'klics'
*
*      macro
*      TOPX      &DG, &HG, &old, &XX
*
*      swap      &HG                      ; HG=G1H0
*      move.w     &DG,&XX                  ; XX=G0
*      neg.w      &DG                      ; DG=D(-G0)
*      add.w      &HG,&DG                  ; DG=DD
*      add.w      &XX,&HG                  ; HG=G1D
*      swap      &HG                      ; HG=DG1
*      move.l     &DG,&old                 ; save DD
*
*      endm

```

```

*-----
*      macro
*      TOPY      &HG0, &new0, &HG1, &new1, &XX
*
*      move.l     &new0,&XX                ; read HG
*      move.l     &new1,&HG1              ; read HG
*      move.l     &HG1,&HG0              ; copy HG
*      add.l      &XX,&HG1              ; new1=H1G1
*      sub.l      &XX,&HG0              ; new0=H0G0
*
*      endm

```

```

*-----
*      macro
*      TOPBLOCK  &DG0, &HG0, &new0, &old0, &DG1, &HG1, &new1, &old1, &XX
*
*      TOPY      &HG0,&new0,&HG1,&new1,&XX
*      TOPX      &DG0,&HG0,&old0,&XX
*      TOPX      &DG1,&HG1,&old1,&XX
*
*      endm

```

```

*-----
*      macro
*      TOPH      &DG, &HG, &new, &old, &XX
*
*      move.l     &new,&HG
*      TOPX      &DG,&HG,&old,&XX
*
*      endm

```

```

*-----
*      macro
*      TOPE      &DG, &old, &XX
*
*      move.l     &DG,&XX                ; XX=DG
*      swap      &XX                    ; XX=GD
*      move.w     &XX,&DG                ; DG=DD
*      move.l     &DG,&old              ; save DD
*
*

```





- 647 -

Engineering:KlicsCode:CompPict:Top.a

```
      unlk      a6      ; remove locals
      rts      ; return
*
      ENDFUNC
*-----
      END
```

- 648 -

Engineering:KlicsCode:CompPict:Table.a

```

-----
*
*   © Copyright 1993 KLICS Ltd.
*   All rights reserved.
*
-----
*
*   680X0 Table Lookup RGB/YUV code
*
-----

```

```

        machine      MC68030
        seg          'klics'

        if &TYPE('seg')≠'UNDEFINED' then
        seg          &seg
        endif

MKTABLE FUNC      EXPORT
.
PS      RECORD      8
Table   DS.L         1
        ENDR

        link         a6,#0
        movem.l      d4-d7/a3-a5,-(a7)      ; store registers

        move.l       PS.Table(a6),a0        ;Table is (long)(2U+512) (long)(512-(6
        clr.l        d0                     ;U value
@MakeLoop
        move.w       #512,d1                ;512

        move.l       d0,d2                  ;U
        move.w       d2,d3                  ;U

        add.w        d2,d2                  ;2U
        add.w        d1,d2                  ;2U + 512..

        lsr.w        #2,d2
        move.w       d2,(a0)+               ;Place 1st word
        move.w       d2,(a0)+               ;Place 2nd word

        add.w        d3,d3                  ;2U
        move.w       d3,d2                  ;2U
        add.w        d3,d3                  ;4U
        add.w        d2,d3                  ;6U
        asr.w        #4,d3                  ;6U/16
        sub.w        d3,d1                  ;512 - (6U/16)

        lsr.w        #2,d1
        move.w       d1,(a0)+               ;Place 1st word
        move.w       d1,(a0)+               ;Place 2nd word

        add.w        #1,d0
        cmp.w        #50200,d0
        bne          @MakeLoop

        move.l       #500000200,d0          ;U value
        clr.l        d4
@MakeNegLoop
        move.w       #512,d1                ;512

        move.w       d0,d2                  ;U

```

- 649 -

Engineering:KlicsCode:CompPict:Table.a

```

or.w      #SFC00,d2
move.w    d2,d3                ;U

add.w     d2,d2                ;2U
add.w     d1,d2                ;2U + 512

asr.w     #2,d2
move.w    d2,(a0)+            ;Place 1st word
move.w    d2,(a0)+            ;Place 2nd word
add.w     d3,d3                ;2U
move.w    d3,d2                ;2U
add.w     d3,d3                ;4U
add.w     d2,d3                ;6U
asr.w     #4,d3                ;6U/16
sub.w     d3,d1                ;512 - (6U/16)

asr.w     #2,d1
move.w    d1,(a0)+            ;Place 1st word
move.w    d1,(a0)+            ;Place 2nd word

add.l     #1,d0
add.l     #1,d4
cmp.w     #S0200,d4
bne       @MakeNegLoop

movem.l   (a7)+,d4-d7/a3-a5    ; restore registers
unlk      a6                   ; remove locals
rts        ; return

ENDFUNC
-----
macro
FIXOV     &V, &SP1, &SP2

move.w    &V,&SP1
clr.b     &SP1
andi.w    #S3FFF,&SP1
sne       &SP1
btst      #13,&SP1
seq       &SP2
or.b      &SP1,&V
and.w     &SP2,&V
swap      &V
move.w    &V,&SP1
clr.b     &SP1
andi.w    #S3FFF,&SP1
sne       &SP1
btst      #13,&SP1
seq       &SP2
or.b      &SP1,&V
and.w     &SP2,&V
swap      &V

endm
-----
if &TYPE('seg')!='UNDEFINED' then
seg      &seg
endif

YUV2RGB4   FUNC      EXPORT
PS         RECORD     8
Table      DS.L       1

```

- 650 -

Engineering:KlicsCode:CompPict:Table.a

```

pixmap DS.L      1
Y       DS.L      1
U       DS.L      1
V       DS.L      1
area    DS.L      1
width   DS.L      1
cols    DS.L      1
        ENDR
*
LS      RECORD    0,DECR
inc     DS.L      1
width   DS.L      1
fend    DS.L      1
count   DS.L      1
LSize   EQU       *
        ENDR
*
*void YUVtoRGB(Ptr TablePtr,long *pixmap,short *Yc,short *Uc,short *Vc,long area,1
*{
*long      inc,lwidth,fend,count;
;          a0 - Y0, a1 - Y1, a2 - U, a3 - V, a4 - pm0, a5 - pml
;          d0..6 - used, d7 - count

        link      a6,#LS.LSize          ; save locals
        movem.l   d0-d7/a0-a5,-(a7)      ; store registers

        move.l    PS.pixmap(a6),a4      ; pm0=pixmap
        move.l    a4,a5                  ; pml=pm0
        move.l    PS.Y(a6),a0            ; Y0=Yc
        move.l    a0,a1                  ; Y1=Y0
        move.l    PS.U(a6),a2            ; U=Uc
        move.l    PS.V(a6),a3            ; V=Vc
        move.l    PS.area(a6),d7         ; fend=area
        lsl.l     #2,d7                  ; fend<=2
        add.l     a4,d7                  ; fend+=pm0
        move.l    d7,LS.fend(a6)         ; save fend
        move.l    PS.width(a6),d5        ; width=width
        move.l    d5,d7                  ; count=width
        asr.l     #1,d7                  ; count>=1
        subq.l    #1,d7                  ; count-=1
        move.l    d7,PS.width(a6)        ; save width

        add.l     d5,d5                  ; width*=2
        add.l     d5,a1                  ; Y1+=width
        add.l     d5,d5                  ; width*=2
        move.l    d5,LS.width(a6)        ; save width

        move.l    PS.cols(a6),d4         ; inc=cols
        lsl.l     #2,d4                  ; inc<=2
        add.l     d4,a5                  ; pml+=inc
        add.l     d4,d4                  ; cols*=2
        sub.l     d5,d4                  ; inc now 2*cols-width bytes
        move.l    d4,LS.inc(a6)          ; save inc

        move.l    a6,-(sp)
        move.l    PS.Table(a6),a6

; Colors wanted are:
; RED      = (Y + 2V + 512) / 4
; GREEN    = (Y - V + 512 - (6U/16)) / 4
; BLUE     = (Y + 2U + 512) / 4
;
;do      ; uv2rgb(*U++,*V++)

```

UTable part is for (2V + 512)  
 UTable part is for (512 - (6U  
 UTable part is for (2U + 512)

- 651 -

Engineering:KlicsCode:CompPict:Table.a

```

d1 - ra, d2 - ga, d3 - ba,    d4 - rb, d5 - gb/512, d6 - bb

move.w    (a2)+,d2                ; U
beq       @DoQuickU
and.w     #$03FF,d2
move.l    (a6,d2.w*8),d3          ;BLUE,Get (2U + 512)/4 for Blue = (Y +
move.l    d3,d6                  ;Dup for second pair
move.l    4(a6,d2.w*8),d5        ;GREEN, Get (512 - (6U/16))/4 for Gree:
@DidQuickU
move.w    (a3)+,d1                ; V
beq       @DoQuickV
move.w    d1,d4                  ;if zero then handle using the quick m
asr.w     #2,d1
sub.w     d1,d5                  ;GREEN, Get (512 - (6U/16) - V)/4 for
move.w    d5,d2
swap      d5
move.w    d2,d5
move.l    d5,d2                  ;Dup for second pair

and.w     #$03FF,d4
move.l    (a6,d4.w*8),d4          ;RED, Get (2V + 512)/4 for Red = (Y +
move.l    d4,d1
bra       @TestEnd
@DoQuickU
move.l    #$00800080,d3          ;BLUE,Get (2U + 512)/4 for Blue = (Y +
move.l    d3,d6                  ;Dup for second pair
move.l    d3,d5                  ;GREEN, Get (512 - (6U/16))/4 for Gree:
bra       @DidQuickU
@DoQuickV
move.l    d5,d2                  ;GREEN, Get (512 - (6U/16) - V)/4 for
move.l    #$00800080,d4          ;RED, Get (2V + 512)/4 for Red = (Y +
move.l    d4,d1                  ;Dup for second pair
@TestEnd

; add Ya to RGB values - FETCHY (a0)+,d0,d1,d2,d3
move.l    (a0)+,d0                ;Y
asr.w     #2,d0
swap      d0
asr.w     #2,d0
swap      d0
add.l     d0,d1
add.l     d0,d2
add.l     d0,d3
;Y is -128 to +127
;RED, Get (Y+ 2V + 512) for Red = (Y +
;GREEN, Get (Y + (512 - (6U/16)) - V)
;BLUE,Get (Y + (2U + 512) for Blue = (

; add Yb to RGB values - FETCHY2 (a1)+,d0,d4,d5,d6
move.l    (a1)+,d0                ;Y
asr.w     #2,d0
swap      d0
asr.w     #2,d0
swap      d0
add.l     d0,d4
add.l     d0,d5
add.l     d0,d6
;Y is -128 to +127
;RED, Get (Y+ 2V + 512) for Red = (Y +
;GREEN, Get (Y + (512 - (6U/16)) - V)
;BLUE,Get (Y + (2U + 512) for Blue = (

move.l    d1,d0
or.l      d4,d0

or.l      d2,d0
or.l      d3,d0
or.l      d5,d0

```

- 652 -

```

f      Engineering:KlicsCode:CompPict:Table.a

or.l      d6,d0

and.l     #FFF0FF00,d0
bne       @over      ; if overflow

@ok      ; save RGBa - MKRGB d1,d2,d3,(a4)+
ls1.l     #8,d2      ; G=G0G0 (12)
or.l      d3,d2      ; G=GBGB (12)
move.l    d1,d3      ; B=0R0R (12)
swap      d3         ; B=0R0R (21)
move.w    d2,d3      ; B=0RGB (2)
swap      d2         ; G=GBGB (21)
move.w    d2,d1      ; R=0RGB (1)
move.l    d1,(a4)+   ; *RGB++=rgb (1)
move.l    d3,(a4)+   ; *RGB++=rgb (2)

; save RGBb - MKRGB d4,d5,d6,(a5)+
ls1.l     #8,d5      ; G=G0G0 (12)
or.l      d6,d5      ; G=GBGB (12)
move.l    d4,d6      ; B=0R0R (12)
swap      d6         ; B=0R0R (21)
move.w    d5,d6      ; B=0RGB (2)
swap      d5         ; G=GBGB (21)
move.w    d5,d4      ; R=0RGB (1)
move.l    d4,(a5)+   ; *RGB++=rgb (1)
move.l    d6,(a5)+   ; *RGB++=rgb (2)

dbf       d7,@do     ; while

move.l    (sp)+,a6

adda.l    LS.inc(a6),a4      ; pm0+=inc
adda.l    LS.inc(a6),a5      ; pm1+=inc
adda.l    LS.width(a6),a0    ; Y0+=width
exg.l     a0,a1              ; Y1<->Y0
move.l    PS.width(a6),d7    ; count=width
cmpa.l    LS.fend(a6),a4     ; pm0<fend
blt.w     @do2              ; while

movem.l   (a7)+,d0-d7/a0-a5  ; restore registers
unlk      a6                ; remove locals
rts

@do2      move.l    a6,-(sp)
move.l    PS.Table(a6),a6
bra       @do              ; return

@FixIt    btst      #31,d0      ;See if upper word went negative
beq       @D1TopNotNeg
and.l     #5000FFFF,d0        ;Pin at zero
@D1TopNotNeg
btst      #24,d0              ;See if upper word went too positive
beq       @D1TopNotPos
and.l     #5000FFFF,d0        ;Mask old data out
or.l      #500FF0000,d0       ;New data is maxed
@D1TopNotPos

btst      #15,d0              ;See if lower word went negative
beq

```

- 653 -

Engineering:KlicsCode:CompPict:Table.a

```

        and.l      #$FFFF0000,d0      ;Pin at zero
@DlBotNotNeg
        btrst      #8,d0              ;See if lower word went too positive
        beq         @DlBotNotPos
        and.l      #$FFFF0000,d0      ;Mask old data out
        or.l        @DlBotNotPos      ;New data is maxed
        #$000000FF,d0
        rts

@over
        move.l      d1,d0
        bsr         @FixIt
        move.l      d0,d1

        move.l      d2,d0
        bsr         @FixIt
        move.l      d0,d2

        move.l      d3,d0
        bsr         @FixIt
        move.l      d0,d3

        move.l      d4,d0
        bsr         @FixIt
        move.l      d0,d4

        move.l      d5,d0
        bsr         @FixIt
        move.l      d0,d5

        move.l      d6,d0
        bsr         @FixIt
        move.l      d0,d6

        bra         @ok

ENDFUNC
-----
END

```



- 654 -

Engineering:KlicsCode:CompPict:KlicsUtil.a

```

*-----
*
*  © Copyright 1993 KLICS Limited
*  All rights reserved.
*
*  Written by: Adrian Lewis
*-----
*
*  68000 Klics Utilities
*-----
*
*      seg      'klics'
*
KLCopy  FUNC      EXPORT
*
*  KLCOPY(short *src, short *dst, int area);
*
PS      RECORD      8
src      DS.L      1
dst      DS.L      1
end      DS.L      1
*      ENDR
*
*      link      a6,#0                      ; no local variables
*
*      move.l     PS.src(a6),a0              ; short *src
*      move.l     PS.dst(a6),a1              ; short *dst
*      move.l     PS.end(a6),d3              ; long area
*      lsr.l      #4,d3                      ; in words(x8)
*      subq.l     #1,d3                      ; area-=1
@do      move.l     (a0)+,(a1)+              ; *dst++=*src++
*      move.l     (a0)+,(a1)+              ; *dst++=*src++
*      move.l     (a0)+,(a1)+              ; *dst++=*src++
*      move.l     (a0)+,(a1)+              ; *dst++=*src++
*      move.l     (a0)+,(a1)+              ; *dst++=*src++
*      move.l     (a0)+,(a1)+              ; *dst++=*src++
*      move.l     (a0)+,(a1)+              ; *dst++=*src++
*      move.l     (a0)+,(a1)+              ; *dst++=*src++
*      dbf        d3,@do                    ; if -1!==-area goto `do
*
*      unlk      a6                          ; remove locals
*      rts                          ; return
*
*      ENDFUNC
*-----
KLHalf  FUNC      EXPORT
*
*  KLHALF(short *src, short *dst, long width, long height);
*  Dimensions of dst (width, height) are half that of src
*
PS      RECORD      8
src      DS.L      1
dst      DS.L      1
width    DS.L      1
height   DS.L      1
*      ENDR
*
*      link      a6,#0                      ; no local variables
*      movem.l    d4,-(a7)                  ; store registers
*
*      move.l     PS.src(a6),a0              ; short *src
*      move.l     PS.dst(a6),a1              ; short *dst

```

- 655 -

Engineering:KlicsCode:CompPict:KlicsUtil.a

```

        move.l    PS.width(a6),d2        ; long width
        move.l    PS.height(a6),d3      ; long height
        subq.l    #1,d3                 ; height-=1
@do_y    move.l    d2,d4                 ; count=width
        lsr.l     #2,d4                 ; count /= 2
        subq.l    #1,d4                 ; count-=1
@do_x    move.l    (a0)+,d0              ; d0=*src++
        move.w    (a0)+,d0              ; d2=*src++
        addq.l    #2,a0                 ; src+=1 short
        move.l    d0,(a1)+              ; *dst++=d0
        move.l    (a0)+,d0              ; d0=*src++
        move.w    (a0)+,d0              ; d2=*src++
        addq.l    #2,a0                 ; src+=1 short
        move.l    d0,(a1)+              ; *dst++=d0
        dbf       d4,@do_x              ; if -1!--width goto do_x
        adda.l    d2,a0                 ; skip a quarter row
        adda.l    d2,a0                 ; skip a quarter row
        adda.l    d2,a0                 ; skip a quarter row
        adda.l    d2,a0                 ; skip a quarter row
        dbf       d3,@do_y              ; if -1!--height goto do_y
*
        movem.l   (a7)+,d4              ; restore registers
        unlk      a6                   ; remove locals
        rts
*
        ENDFUNC
*-----
KLZero  FUNC      EXPORT
*
*      KLZERO(short *data, int area);
*
PS      RECORD      8
data    DS.L        1
end     DS.L        1
        ENDR
*
        link       a6,#0               ; no local variables
*
        move.l     PS.data(a6),a0      ; short *data
        move.l     PS.end(a6),d3      ; long area
        lsr.l      #3,d3               ; in words(x4)
        subq.l     #1,d3               ; area-=1
@do     clr.l      (a0)+                ; *dst++=*src++
        clr.l      (a0)+                ; *dst++=*src++
        clr.l      (a0)+                ; *dst++=*src++
        clr.l      (a0)+                ; *dst++=*src++
        dbf        d3,@do              ; if -1!--area goto do
*
        unlk       a6                  ; remove locals
        rts
*
        ENDFUNC
*-----
CLEARA2 FUNC      EXPORT
*
        move.l     #0,a2
        rts
*
        END

```

- 656 -

Engineering:KlicsCode:CompPict:KlicsEncode.h

```

/*****
 *
 *  © Copyright 1993 KLICS Limited
 *  All rights reserved.
 *
 *  Written by: Adrian Lewis
 *
 *****/
typedef struct {
    int      bpf_in,      /* User - Bytes per frame in input stream */
             bpf_out,     /* User - Bytes per frame in output stream */
             buf_size;    /* User - Buffer size (bytes) */

    Boolean  intra,       /* Calc - Compression mode intra/inter */
             auto_q,      /* User - Automatic quantization for rate control */
             buf_sw;      /* User - Theoretical buffer on/off */

    float    quant,       /* User - Starting quantiser value */
             thresh,      /* User - Threshold factor */
             compare,     /* User - Comparison factor */
             base[5];     /* User - Octave weighting factors */

    int      buffer,      /* Calc - Current buffer fullness (bytes) */
             prevbytes,   /* Calc - Bytes sent last frame */
             prevquact;   /* Calc - Quantisation/activity for last frame */

    double   tmp_quant;   /* Calc - Current quantiser value quant */
} KlicsEDataRec;

typedef struct {
    KlicsSeqHeader      seqh;
    KlicsFrameHeader    frmh;
    KlicsEDataRec       encd;
    Buffer               buf;
} KlicsERec, *KlicsE;

```

- 657 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```

-----
*
*  © Copyright 1993 KLICS Limited
*  All rights reserved.
*
*  Written by: Adrian Lewis
*
-----
*
*  680X0 KlicsDecode code
*  Fast code for:
*    3/2 octave input stream
*    2/1 octave output image
*
-----
*
*      seg      'klics'
*      include  'Bits3.a'
*      include  'Traps.a'
*
-----
*
*      machine      MC68030
*
*****
*
*  Data stream readers:
*
*  XDELTA, XVALUE, SKIPHUFF, XINT
*
*****
*
*      macro
*      XDELTA      &addr,&step,&ptr,&data,&bno,&spare
*
*      buf_rinc    &ptr,&data,&bno      ;
*      buf_get     &data,&bno          ;
*      beq.s       @quit              ; if zero write
*      moveq       #6,&spare          ; set up count
*      buf_get     &data,&bno          ; read sign
*      bne.s       @doneg            ; if negative -> doneg
*
*  @dopos  buf_get  &data,&bno
*          dbne     &spare,@dopos      ; if --spare!--1
*          bne.s    @findpos
*
*          move.l   &data,&spare      ; spare=data
*          subq.b   #7,&bno           ; bno-=6
*          lsr.l    &bno,&spare       ; spare>>=bno
*          andi.w   #5007F,&spare    ; spare AND= mask
*          add.w    #8,&spare         ; spare+=9
*          bra.s    @write
*
*  @findpos neg.w    &spare            ; bits-=bits
*          addq.l   #7,&spare         ; bits+=8
*          bra.s    @write
*
*  @doneg  buf_get  &data,&bno
*          dbne     &spare,@doneg     ; if --spare!--1
*          bne.s    @findneg
*
*          move.l   &data,&spare      ; spare=data
*          subq.b   #7,&bno           ; bno-=6
*          lsr.l    &bno,&spare       ; spare>>=bno
*          andi.w   #5007F,&spare    ; spare AND= mask

```

- 658 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```

        add.w    #8,&spare          ; spare+=9
        neg.w    &spare
        bra.s    @write

@fndneg subq.l    #7,&spare          ; level-=8

@write lsl.w     &step,&spare        ; level<=&step
        swap     &step
        add.w    &step,&spare
        swap     &step
        add.w    &spare,&addr      ; *addr=delta
@quit
*
        endm

        macro
        XVAL0      &addr,&step,&ptr,&data,&bno,&spare

        clr.w     &spare
        buf_rinc   &ptr,&data,&bno    ;
        buf_get    &data,&bno        ;
        beq.s      @quit              ; if zero write
        moveq      #6,&spare          ; set up count
        buf_get    &data,&bno        ; read sign
        bne.s      @doneg            ; if negative -> doneg

@dopos buf_get    &data,&bno
        dbne       &spare,@dopos      ; if --spare!--1
        bne.s      @fndpos

        move.l     &data,&spare        ; spare=data
        subq.b     #7,&bno             ; bno-=6
        lsr.l      &bno,&spare         ; spare>>=bno
        andi.w     #007F,&spare        ; spare AND= mask
        add.w      #8,&spare          ; spare+=9
        bra.s      @write

@fndpos neg.w     &spare              ; bits-=bits
        addq.l     #7,&spare          ; bits+=8
        bra.s      @write

@doneg buf_get    &data,&bno
        dbne       &spare,@doneg      ; if --spare!--1
        bne.s      @fndneg

        move.l     &data,&spare        ; spare=data
        subq.b     #7,&bno             ; bno-=6
        lsr.l      &bno,&spare         ; spare>>=bno
        andi.w     #007F,&spare        ; spare AND= mask
        add.w      #8,&spare          ; spare+=9
        neg.w      &spare
        bra.s      @write

@fndneg subq.l    #7,&spare          ; level-=8

@write lsl.w     &step,&spare        ; level<=&step
        swap     &step
        add.w    &step,&spare
        swap     &step
        move.w    &spare,&addr      ; *addr=level
@quit
*
        endm

```

- 659 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```

macro
XVAL1      &addr,&step,&ptr,&data,&bno,&spare

    clr.w      &spare
    buf_rinc   &ptr,&data,&bno      ;
    buf_get    &data,&bno          ;
    beq.s      @quit                ; if zero write
    moveq      #6,&spare            ; set up count
    buf_get    &data,&bno          ; read sign
    bne.s      @doneg              ; if negative -> doneg

@dopos      buf_get    &data,&bno
            dbne       &spare,@dopos      ; if --spare!--1
            bne.s      @fndpos

            move.l     &data,&spare      ; spare=data
            subq.b     #7,&bno           ; bno--6
            lsr.l      &bno,&spare      ; spare>>=bno
            andi.w     #$007F,&spare    ; spare AND= mask
            add.w      #8,&spare        ; spare+=9
            bra.s      @write

@fndpos     neg.w      &spare            ; bits-=bits
            addq.l     #7,&spare        ; bits+=8
            bra.s      @write

@doneg      buf_get    &data,&bno
            dbne       &spare,@doneg     ; if --spare!--1
            bne.s      @fndneg

            move.l     &data,&spare      ; spare=data
            subq.b     #7,&bno           ; bno--6
            lsr.l      &bno,&spare      ; spare>>=bno
            andi.w     #$007F,&spare    ; spare AND= mask
            add.w      #8,&spare        ; spare+=9
            neg.w      &spare
            bra.s      @write

@fndneg     subq.l     #7,&spare          ; level-=8

@write      lsl.w      &step,&spare      ; level<=step
@quit       move.w     &spare,&addr     ; *addr=level
            endm

macro
SKIPHUFF      &ptr,&data,&bno,&spare

    buf_get    &data,&bno      ;
    beq.s      @quit          ; if zero quit
    buf_get    &data,&bno      ; skip sign
    moveq      #6,&spare      ; set up count

@do           buf_get    &data,&bno
            dbne       &spare,@do      ; if --spare!--1
            bne.s      @end

            subq.b     #7,&bno          ; bno--6
            buf_rinc   &ptr,&data,&bno  ; fill buffer

@end
@quit
            endm

```

- 660 -

Engineering:KlicsCode:CompFict:KlicsDec2.a

```

macro
XINTX      &bits,&addr,&step,&ptr,&data,&bno
*
*   Note: half_q is missing
*
    buf_rinc    &ptr,&data,&bno      ;
    move.l      &data,d0            ; result=data
    sub.b       &bits,&bno          ; dl==bits-1
    subq.b      #1,&bno              ; dl-=1
    lsr.l       &bno,d0             ; result>>=bno
    clr.l       dl                  ; dl=0
    bset        &bits,dl            ; dl[bits]=1
    subq.l      #1,dl               ; dl=mask
    btst        &bits,d0            ; sign?
    beq.s       @pos                ; if positive goto pos
    and.l       dl,d0               ; apply mask leaving level
    neg.l       d0                  ; level-=level
    bra.s       @cont               ; goto cont
@pos        and.l   dl,d0            ; apply mask leaving level
@cont       lsl.l   &step,d0         ; level<=&step
            move.w   d0,&addr        ; *addr=result
*
    endm

macro
XINT      &bits,&addr,&step,&ptr,&data,&bno
*
*   Hardware compatible version: sign mag(lsb->msb)
*
    buf_rinc    &ptr,&data,&bno      ;
    move.l      &data,d0            ; result=data
    sub.b       &bits,&bno          ; dl==bits-1
    subq.b      #1,&bno              ; dl-=1
    lsr.l       &bno,d0             ; temp>>=bno
    clr.l       dl                  ; result=0
    swap        &bno                ; use free word
    move.w       &bits,&bno          ; bno=bnc, bits
    subq.w      #1,&bno              ; count=bits-2
@shft        lsr.l   #1,d0           ; shift msb from temp
            roxl.l   #1,dl           ; into lsb of result
            dbf      &bno,@shft      ; for entire magnitude
    swap        &bno                ; restore bno
    btst        #0,d0               ; sign test
    beq.s       @pos                ; if positive -> pos
    neg.l       dl                  ; result= -result
@pos         lsl.l   &step,dl        ; result<=&step
            move.w   dl,&addr        ; *addr=result
*
    endm

*****
*
*   Block data read/write:
*
*   VOID, STILL, SEND, LPFSTILL
*
*****

macro
VOID      &x_blk, &y_blk
*
    clr.w   (a2)

```

- 661 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```

addq.l    &x_blk,a2          ; caddr+=x_blk
clr.w     (a2)
adda.w    &y_blk,a2          ; caddr+=y_blk
clr.w     (a2)
addq.l    &x_blk,a2          ; caddr+=x_blk
clr.w     (a2)
*
endm

macro
STILL      &x_blk, &y_blk, &step

XVAL0     (a2),&step,a0,d6,d7,d0
addq.l    &x_blk,a2          ; caddr+=x_blk
XVAL0     (a2),&step,a0,d6,d7,d0
adda.w    &y_blk,a2          ; caddr+=y_blk
XVAL0     (a2),&step,a0,d6,d7,d0
addq.l    &x_blk,a2          ; caddr+=x_blk
XVAL0     (a2),&step,a0,d6,d7,d0
*
endm

macro
STILLSEND  &x_blk, &y_blk, &step

XVAL1     (a2),&step,a0,d6,d7,d0
addq.l    &x_blk,a2          ; caddr+=x_blk
XVAL1     (a2),&step,a0,d6,d7,d0
adda.w    &y_blk,a2          ; caddr+=y_blk
XVAL1     (a2),&step,a0,d6,d7,d0
addq.l    &x_blk,a2          ; caddr+=x_blk
XVAL1     (a2),&step,a0,d6,d7,d0
*
endm

macro
SEND       &x_blk,&y_blk,&step

XDELTA    (a2),&step,a0,d6,d7,d0
addq.l    &x_blk,a2          ; caddr+=x_blk
XDELTA    (a2),&step,a0,d6,d7,d0
adda.w    &y_blk,a2          ; caddr+=y_blk
XDELTA    (a2),&step,a0,d6,d7,d0
addq.l    &x_blk,a2          ; caddr+=x_blk
XDELTA    (a2),&step,a0,d6,d7,d0
*
endm

macro
LPFSTILL   &x_blk, &y_blk, &step, &bits

XINT      &bits,(a2),&step,a0,d6,d7 ; ReadInt (at baddr)
addq.l    &x_blk,a2          ; caddr+=x_blk
XINT      &bits,(a2),&step,a0,d6,d7 ; ReadInt
adda.w    &y_blk,a2          ; caddr+=y_blk
XINT      &bits,(a2),&step,a0,d6,d7 ; ReadInt
addq.l    &x_blk,a2          ; caddr+=x_blk
XINT      &bits,(a2),&step,a0,d6,d7 ; ReadInt
*
endm

```

\*\*\*\*\*



- 662 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

\* Data skipping:

\* SKIP4, STILLSKIP, SS\_SKIP, SENDSKIP

\*\*\*\*\*

SKIP4 FUNC EXPORT

```

*
    buf_rinc    a0,d6,d7          ; fill buffer
    SKIPHUFF    a0,d6,d7,d0
    SKIPHUFF    a0,d6,d7,d0
    SKIPHUFF    a0,d6,d7,d0
    SKIPHUFF    a0,d6,d7,d0
    rts

```

ENDFUNC

STILLSKIP FUNC EXPORT

```

*
    buf_rinc    a0,d6,d7          ; BUF_INC
    buf_get     d6,d7             ; BUF_GET
    beq.s       @sk1              ; if 0 the STOP
    bsr         SKIP4
    buf_rinc    a0,d6,d7          ; BUF_INC
@sk1  buf_get     d6,d7             ; BUF_GET
    beq.s       @sk2              ; if 0 the STOP
    bsr         SKIP4
    buf_rinc    a0,d6,d7          ; BUF_INC
@sk2  buf_get     d6,d7             ; BUF_GET
    beq.s       @sk3              ; if 0 the STOP
    bsr         SKIP4
    buf_rinc    a0,d6,d7          ; BUF_INC
@sk3  buf_get     d6,d7             ; BUF_GET
    beq.s       @nxt              ; if 0 the STOP
    bsr         SKIP4
@nxt  rts

```

ENDFUNC

SS\_SKIP FUNC EXPORT

```

*
    buf_rinc    a0,d6,d7          ; BUF_INC
    buf_get     d6,d7             ; BUF_GET
    beq.s       @sk1              ; if 0 then STOP
    buf_get     d6,d7             ; BUF_GET
    bne.s       @sk1              ; if 1 then VOID
    bsr         SKIP4
    buf_rinc    a0,d6,d7          ; BUF_INC
@sk1  buf_get     d6,d7             ; BUF_GET
    beq.s       @sk2              ; if 0 then STOP
    buf_get     d6,d7             ; BUF_GET
    bne.s       @sk2              ; if 1 then VOID
    bsr         SKIP4
    buf_rinc    a0,d6,d7          ; BUF_INC
@sk2  buf_get     d6,d7             ; BUF_GET
    beq.s       @sk3              ; if 0 then STOP
    buf_get     d6,d7             ; BUF_GET
    bne.s       @sk3              ; if 1 then VOID
    bsr         SKIP4
    buf_rinc    a0,d6,d7          ; BUF_INC
@sk3  buf_get     d6,d7             ; BUF_GET
    beq.s       @nxt              ; if 0 then STOP
    buf_get     d6,d7             ; BUF_GET

```

- 663 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```

        bne.s      @nxt      ; if 1 then VOID
        bsr        SKIP4
@nxt    rts
*
        ENDFUNC

SENDSKIP?  FUNC      EXPORT
*
        buf_rinc    a0,d6,d7      ; BUF_INC

        buf_get     d6,d7      ; BUF_GET
        beq.s       @sk1      ; if 0 the STOP
        buf_get     d6,d7      ; BUF_GET
        beq.s       @sk0      ; if 0 then STILLSEND
        buf_get     d6,d7      ; BUF_GET
        beq.s       @sk1      ; if 0 then VOID

@sk0     bsr        SKIP4
        buf_rinc    a0,d6,d7      ; BUF_INC

@sk1     buf_get     d6,d7      ; BUF_GET
        beq.s       @sk3      ; if 0 the STOP
        buf_get     d6,d7      ; BUF_GET
        beq.s       @sk2      ; if 0 then STILLSEND
        buf_get     d6,d7      ; BUF_GET
        beq.s       @sk3      ; if 0 then VOID

@sk2     bsr        SKIP4
        buf_rinc    a0,d6,d7      ; BUF_INC

@sk3     buf_get     d6,d7      ; BUF_GET
        beq.s       @sk5      ; if 0 the STOP
        buf_get     d6,d7      ; BUF_GET
        beq.s       @sk4      ; if 0 then STILLSEND
        buf_get     d6,d7      ; BUF_GET
        beq.s       @sk5      ; if 0 then VOID

@sk4     bsr        SKIP4
        buf_rinc    a0,d6,d7      ; BUF_INC

@sk5     buf_get     d6,d7      ; BUF_GET
        beq.s       @nxt      ; if 0 then STOP
        buf_get     d6,d7      ; BUF_GET
        beq.s       @sk6      ; if 0 then STILLSEND
        buf_get     d6,d7      ; BUF_GET
        beq.s       @nxt      ; if 0 then VOID

@sk6     bsr        SKIP4
@nxt     rts
*
        ENDFUNC

```

```

*****
*
*   Octave Processing:
*
*   DOSTILL0, DOSEND0, DOSTILL1,
*   DOVOID1, DOSTILLSSEND1, DOSEND1
*****

```

```

DOSTILL0  FUNC      EXPORT
*

```

- 664 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```

        buf_rinc    a0,d6,d7          ; BUF_INC
        buf_get     d6,d7             ; BUF_GET
        bne.s       @still            ; if 1 the STILL
        rts

@still  move.l      a1,a2              ; caddr=baddr

*      STILL        #4,d5,d3

        XVAL0       (a2),d3,a0,d6,d7,d0
        addq.l      #4,a2              ; caddr+=x_blk
        XVAL0       (a2),d3,a0,d6,d7,d0
        adda.w      d5,a2              ; caddr+=y_blk
        XVAL0       (a2),d3,a0,d6,d7,d0
        addq.l      #4,a2              ; caddr+=x_blk
        XVAL0       (a2),d3,a0,d6,d7,d0

        bsr         STILLSKIP
        rts

        .
        ENDFUNC

DOSEND0 FUNC      EXPORT
        .
        buf_rinc    a0,d6,d7          ; BUF_INC
        buf_get     d6,d7             ; BUF_GET
        bne.s       @cont            ; if 1 then continue
        rts

@cont   move.l      a1,a2              ; caddr=baddr
        buf_get     d6,d7             ; BUF_GET
        beq.w       @ss              ; if 0 then STILLSEND
        buf_get     d6,d7             ; BUF_GET
        beq.w       @vd              ; if 0 then VOID

        .
        SEND        #4,d5,d3

        XDELTA      (a2),d3,a0,d6,d7,d0
        addq.l      #4,a2              ; caddr+=x_blk
        XDELTA      (a2),d3,a0,d6,d7,d0
        adda.w      d5,a2              ; caddr+=y_blk
        XDELTA      (a2),d3,a0,d6,d7,d0
        addq.l      #4,a2              ; caddr+=x_blk
        XDELTA      (a2),d3,a0,d6,d7,d0

        bsr         SENDSKIP
        rts

@ss     ;STILLSEND  #4,d5,d3

        XVAL1       (a2),d3,a0,d6,d7,d0
        addq.l      #4,a2              ; caddr+=x_blk
        XVAL1       (a2),d3,a0,d6,d7,d0
        adda.w      d5,a2              ; caddr+=y_blk
        XVAL1       (a2),d3,a0,d6,d7,d0
        addq.l      #4,a2              ; caddr+=x_blk
        XVAL1       (a2),d3,a0,d6,d7,d0

        bsr         SS_SKIP
        rts

@vd     ;VOID       #4,d5

```

- 665 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```

        clr.w      (a2)
        addq.l     #4,a2
        clr.w      (a2)          ; caddr+=x_blk
        adda.w     d5,a2
        clr.w      (a2)          ; caddr+=y_blk
        addq.l     #4,a2
        clr.w      (a2)          ; caddr+=x_blk
        rts

*
        ENDFUNC

        macro
        DOSTILL1      &addr

        buf_get      d6,d7
        beq.w         @next          ; BUF_GET
                                      ; if 0 the STOP

        move.l       a1,a2
        add.l         &addr,a2        ; caddr=baddr
        STILL        #4,d5,d4        ; caddr+=addrs[1]
        bsr          STILLSKIP
        buf_rinc      a0,d6,d7
        @next
                                      ; BUF_INC

        *
        endm

        macro
        DOVOID1      &addr

        move.l       a1,a2
        add.l         &addr,a2        ; caddr=baddr
        VOID         #4,d5            ; caddr+=addrs[1]

        *
        endm

        macro
        DOSTILLSEND1  &addr

        buf_get      d6,d7
        beq.w         @next          ; BUF_GET
                                      ; if 0 the STOP
        move.l       a1,a2
        add.l         &addr,a2        ; caddr=baddr
        buf_get      d6,d7
        beq.s         @ss            ; caddr+=addrs[1]
                                      ; BUF_GET
                                      ; if 0 then STILLSEND

        VOID         #4,d5
        bra          @next

        @ss          STILLSEND      #4,d5,d4
        bsr          SS_SKIP
        buf_rinc      a0,d6,d7
        @next
                                      ; BUF_INC

        *
        endm

        DOSTILL2      FUNC      EXPORT

        buf_rinc      a0,d6,d7
        buf_get      d6,d7
        bne.s         @cont          ; BUF_INC
                                      ; BUF_GET
                                      ; if 1 the CONT

        @cont        move.l       a1,a2
                                      ; caddr=baddr

```

- 666 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```

add.l      (a3),a2
STILL      #8,d5,d3          ; caddr+=addrs[0]

swap       d5
exg        d4,a5

buf_rinc   a0,d6,d7          ; BUF_INC
DOSTILL1   4(a3)
DOSTILL1   8(a3)
DOSTILL1   12(a3)
DOSTILL1   16(a3)

swap       d5
exg        d4,a5
rts

macro
DOSEND1    &addr

    buf_get   d6,d7          ; BUF_GET
    beq.w     @next          ; if 0 the STOP
    move.l    a1,a2          ; caddr=baddr
    add.l     &addr,a2       ; caddr+=addrs[1]
    buf_get   d6,d7          ; BUF_GET
    beq.w     @ss            ; if 0 then STILLSEND
    buf_get   d6,d7          ; BUF_GET
    beq.w     @vd            ; if 0 then VOID

    SEND      #4,d5,d4
    bsr       SENDSKIP
    bra       @rinc

@vd        VOID             #4,d5
bra        @next

@ss        STILLSEND       #4,d5,d4
bsr        SS_SKIP
@rinc      buf_rinc         a0,d6,a7          ; BUF_INC
@next

endm

DOSEND2 FUNC    EXPORT
.
    buf_rinc   a0,d6,d7          ; BUF_INC
    buf_get   d6,d7          ; BUF_GET
    bne.s     @cont          ; if 1 the CONT
@nxt       rts

@cont      move.l    a1,a2          ; caddr=baddr
    add.l     (a3),a2       ; caddr+=addrs[0]
    buf_get   d6,d7          ; BUF_GET
    beq.w     @ss            ; if 0 then STILLSEND
    buf_get   d6,d7          ; BUF_GET
    beq.w     @vd            ; if 0 then VOID

*** SEND ***

SEND      #8,d1,d3

buf_rinc   a0,d6,d7          ; BUF_INC
DOSEND1    4(a3)
DOSEND1    8(a3)

```

- 667 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```

DOSEND1      12(a3)
DOSEND1      16(a3)
rts

*** STILLSEND ***

@ss      STILLSEND      #8,d1,d3

      buf_rinc      a0,d6,d7      ; BUF_INC
      DOSTILLSEND1      4(a3)
      DOSTILLSEND1      8(a3)
      DOSTILLSEND1      12(a3)
      DOSTILLSEND1      16(a3)
      rts

*** VOID ***

@vd      VOID      #8,d1

      DOVOID1      4(a3)
      DOVOID1      8(a3)
      DOVOID1      12(a3)
      DOVOID1      16(a3)
      rts

*
      ENDFUNC

      macro
      UVSTILLO
*
*      Low_Pass
*
      move.l      a1,a2      ; caddr=baddr
      LPFSTILL      #4,d5,d2,d4
*
*      Sub-band gh
*
      addq.l      #2,a1      ; baddr+=2 (gh band)
      bsr      DOSTILLO
*
*      Sub-band hg
*
      subq.l      #2,a1      ; baddr-=2 (hh band)
      add.l      a4,a1      ; caddr+=1 row (hg band)
      bsr      DOSTILLO
*
*      Sub-band gg
*
      addq.l      #2,a1      ; baddr+=2 (gg band)
      bsr      DOSTILLO
      sub.l      a4,a1      ; caddr-=1 row (gh band)
      addq.l      #6,a1      ; (2+) addr[0]+=x_inc
*
      endm

      macro
      UVSEND0
*
*      Low_Pass
*
      buf_rinc      a0,d6,d7      ; BUF_INC
      buf_get      d6,d7      ; BUF_GET
      beq.w      @subs      ; if 0 then process subbands

```

- 668 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```

        move.l    a1,a2                ; caddr=baddr
        SEND      #4,d5,d2
    *
    *   Sub-band gh
    *
@subs    addq.l    #2,a1                ; baddr+=2 (gh band)
        bsr      DOSEND0
    *
    *   Sub-band hg
    *
        subq.l    #2,a1                ; baddr-=2 (hh band)
        add.l     a4,a1                ; caddr+=1 row (hg band)
        bsr      DOSEND0
    *
    *   Sub-band gg
    *
        addq.l    #2,a1                ; baddr+=2 (gg band)
        bsr      DOSEND0
        sub.l     a4,a1                ; caddr-=1 row (gh band)
        addq.l    #6,a1                ; (2+) addr[0]+=x_inc
    *
        endm

*****
*
*   Decoder functions:
*
*   Klics2D1Still, Klics2D1Send
*
*****

Klics2D1Still    FUNC    EXPORT
*
*   Klics2D1Still(short *dst, long size_x, long size_y, long lpfbits, short *norms
*
PS        RECORD      8
dst       DS.L         1
size_x    DS.L         1
size_y    DS.L         1
lpfbits   DS.L         1
norms     DS.L         1
ptr       DS.L         1
data      DS.L         1
bno       DS.L         1
        ENDR
*
LS        RECORD      0,DECR
x_lim     DS.L         1
x_linc    DS.L         1
y_inc0    DS.L         1
y_incl    DS.L         1
y_lim     DS.L         1
LSize     EQU          *
        ENDR
*
*   d0/d1 - spare
*   d2 - step 0 (HH)
*   d3 - step 0
*   d4 - lpfbits
*   d5 - y_blk
*   d6 - data (bit stream)
*   d7 - bno (bit pointer)

```

- 669 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```

*   a0 - ptr      (bit buffer)
*   a1 - baddr    (block address)
*   a2 - caddr    (coeff address)
*   a3 - x_lim
*   a4 - x_linc
*   a5 - y_inc0
*
*       link      a6,#LS.LSize      ; locals
*       movem.l   d4-d7/a3-a5,-(a7) ; store registers
*
*   Load Bit Buffer
*
*       move.l     PS.data(a6),a0    ; a0=&data
*       move.l     (a0),d6            ; data=*a0
*       move.l     PS.bno(a6),a0     ; a0=&mask
*       move.l     (a0),d7            ; mask=*a0
*       move.l     PS.ptr(a6),a0     ; a0=&ptr
*       move.l     (a0),a0            ; a0=ptr
*
*   Set Up Block Counters
*
*       move.l     PS.dst(a6),a1      ; a1=image
*       move.l     PS.size_x(a6),d0   ; d0=size_x
*       add.l      d0,d0               ; in shorts
*       move.l     d0,LS.x_linc(a6)   ; x_linc=1 row
*       move.l     PS.size_y(a6),d1   ; d1=size_y
*       muls.w     d0,d1               ; d1*=d0 (area)
*       add.l      a1,d1               ; d1+=image
*       move.l     d1,LS.y_lim(a6)    ; y_lim=d1
*       move.l     d0,d2               ; d2=d0 (1 row)
*       add.l      d0,d0               ; d0*=2 (2 rows)
*       move.l     d0,d5               ; y_blk=d0
*       subq.l     #4,d5               ; y_blk-=x_blk
*       add.l      d0,d0               ; d0*=2 (4 rows)
*       move.l     d0,LS.y_inc0(a6)   ; y_inc0=d0
*       add.l      d0,d0               ; d0*=2 (8 rows)
*       sub.l      d2,d0               ; d0-=d2 (7 rows)
*       move.l     d0,LS.y_inc1(a6)   ; y_inc1=d0
*
*       move.l     PS.norms(a6),a2    ; GetNorm pointer
*       move.l     (a2),d2             ; read normal
*       move.l     4(a2),d3            ; read normal
*       move.l     PS.lpfbits(a6),d4  ; read lpfbits
*       move.l     LS.x_linc(a6),a4    ; read x_linc
*       move.l     LS.y_inc0(a6),a5    ; read y_inc0
*
*   @y   move.l     a4,a3               ; x_lim=x_linc
*         add.l     a1,a3               ; x_lim+=baddr
*   @x   UVSTILLO
*         UVSTILLO
*         add.l     a5,a1               ; process UV block 0,0
*         cmp.l     LS.y_lim(a6),a1    ; (2) addr[0]+=y_inc
*         bge.w     @last              ; (2+) addr[0]-limit?
*         sub.l     #16,a1              ; if half height
*         UVSTILLO
*         UVSTILLO
*   @last sub.l     a5,a1               ; pointer=blk(0,1)
*         ; process UV block 0,1
*         ; process UV block 1,1
*         ; (2) addr[0]+=y_inc
*
*       cmp.l     a3,a1                ; (2+) addr[0]-limit?
*       blt.w     @x                   ; (4) if less then loopX
*       add.l     LS.y_inc1(a6),a1     ; (2+) addr[0]+=y_inc
*       cmp.l     LS.y_lim(a6),a1     ; (2+) addr[0]-limit?
*       blt.w     @y                   ; (4) if less then loopY

```



- 670 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```

*
*   Save Bit Buffer
*
        move.l    PS.data(a6),a2        ; spare=&data
        move.l    d6,(a2)                ; update data
        move.l    PS.bno(a6),a2         ; spare=&bno
        move.l    d7,(a2)                ; update bno
        move.l    PS.ptr(a6),a2         ; spare=&ptr
        move.l    a0,(a2)                ; update ptr
*
        movem.l   (a7)+,d4-d7/a3-a5     ; restore registers
        unlk      a6                     ; remove locals
        rts                                     ; return
*
        ENDFUNC
*-----*
Klics2D1Send    FUNC    EXPORT
*
*   Klics2D1Send(short *dst, long size_x, long size_y, short *norms, unsigned long
*
PS      RECORD      8
dst     DS.L         1
size_x  DS.L         1
size_y  DS.L         1
norms   DS.L         1
ptr     DS.L         1
data    DS.L         1
bno     DS.L         1
        ENDR
*
LS      RECORD      0,DECR
x_lim   DS.L         1
x_linc  DS.L         1
y_inc0  DS.L         1
y_inc1  DS.L         1
y_lim   DS.L         1
LSize   EQU          *
        ENDR
*
*   d0/d1 - spare
*   d2 - step 0 (HH)
*   d3 - step 0
*   d4 - y_inc0
*   d5 - y_blk
*   d6 - data (bit stream)
*   d7 - bno (bit pointer)
*
*   a0 - ptr (bit buffer)
*   a1 - baddr (block address)
*   a2 - caddr (coeff address)
*   a3 - x_lim
*   a4 - x_linc
*   a5 - y_lim
*
        link      a6,#LS.LSize          ; locals
        movem.l   d4-d7/a3-a5,-(a7)     ; store registers
*
*   Load Bit Buffer
*
        move.l    PS.data(a6),a0        ; a0=&data
        move.l    (a0),d6                ; data=*a0
        move.l    PS.bno(a6),a0         ; a0=&mask
        move.l    (a0),d7                ; mask=*a0

```

- 671 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```

        move.l    PS.ptr(a6),a0          ; a0=&ptr
        move.l    (a0),a0                ; a0=ptr
*
*   Set Up Block Counters
*
        move.l    PS.dst(a6),a1          ; a1=image
        move.l    PS.size_x(a6),d0       ; d0=size_x
        add.l     d0,d0                   ; in shorts
        move.l    d0,LS.x_linc(a6)       ; x_linc=1 row
        move.l    PS.size_y(a6),d1       ; d1=size_y
        muls.w    d0,d1                   ; d1*=d0 (area)
        add.l     a1,d1                   ; d1+=image
        move.l    d1,LS.y_lim(a6)        ; y_lim=d1
        move.l    d0,d2                   ; d2=d0 (1 row)
        add.l     d0,d0                   ; d0*=2 (2 rows)
        move.l    d0,d5                   ; copy to d5
        subq.l    #4,d5                   ; subtract x_blk
        add.l     d0,d0                   ; d0*=2 (4 rows)
        move.l    d0,LS.y_inc0(a6)        ; y_inc0=d0
        add.l     d0,d0                   ; d0*=2 (8 rows)
        sub.l     d2,d0                   ; d0-=d2 (7 rows)
        move.l    d0,LS.y_incl(a6)        ; y_incl=d0

        move.l    PS.norms(a6),a2         ; GetNorm pointer
        move.l    (a2),d2                 ; read normal
        move.l    4(a2),d3                ; read normal
        move.l    LS.x_linc(a6),a4         ; read x_linc
        move.l    LS.y_inc0(a6),d4         ; read y_inc0
        move.l    LS.y_lim(a6),a5         ; read y_lim

@y      move.l    a4,a3                   ; x_lim=x_linc
        add.l     a1,a3                   ; x_lim+=baddr
@x      UVSEND0
        UVSEND0
        add.l     d4,a1                   ; process UV block 0,0
        cmp.l     a5,a1                   ; process UV block 1,0
        bge.w     @last                  ; (2) addr[0]+=y_inc
        sub.l     #16,a1                  ; (2) addr[0]-limit?
        UVSEND0
        UVSEND0
        sub.l     d4,a1                   ; if half height
        cmp.l     a3,a1                   ; pointer=blk(0,1)
        blt.w     @x                     ; process UV block 0,1
        cmp.l     LS.y_incl(a6),a1        ; process UV block 1,1
        cmp.l     a5,a1                   ; (2) addr[0]+=y_inc
        blt.w     @y                     ; (2) addr[0]-limit?
        cmp.l     a3,a1                   ; (4) if less then loopX
        add.l     LS.y_incl(a6),a1        ; (2+) addr[0]+=y_inc
        cmp.l     a5,a1                   ; (2) addr[0]-limit?
        blt.w     @y                     ; (4) if less then loopY
*
*   Save Bit Buffer
*
        move.l    PS.data(a6),a2          ; spare=&data
        move.l    d6,(a2)                 ; update data
        move.l    PS.bno(a6),a2           ; spare=&bno
        move.l    d7,(a2)                 ; update bno
        move.l    PS.ptr(a6),a2           ; spare=&ptr
        move.l    a0,(a2)                 ; update ptr
*
        movem.l   (a7)+,d4-d7/a3-a5       ; restore registers
        unlk      a6                     ; remove locals
        rts
*
ENDFUNC
-----

```

- 672 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```

Klics3D2Still  FUNC  EXPORT
*
*   Klics3D2Still(short *dst, long size_x, long size_y, long lpfbits, short *norms
*
PS      RECORD      8
dst     DS.L         1
size_x  DS.L         1
size_y  DS.L         1
lpfbits DS.L         1
norms   DS.L         1
ptr     DS.L         1
data    DS.L         1
bnc     DS.L         1
sub_tab DS.L         1
        ENDR
*
LS      RECORD      0,DECR
y_blk0  DS.L         1
y_blk1  DS.L         1
x_inc   DS.L         1
x_lim   DS.L         1
x_linc  DS.L         1
y_inc   DS.L         1
y_lim   DS.L         1
LSize   EQU          *
        ENDR
*
*   d0/d1 - spare
*   d2 - step 2HH
*   d3 - step 1
*   d4 - step 0/lpfbits
*   d5 - y_blk0,y_blk1
*   d6 - data    (bit stream)
*   d7 - bno     (bit pointer)
*
*   a0 - ptr     (bit buffer)
*   a1 - baddr   (block address)
*   a2 - caddr   (coeff address)
*   a3 - addrs   (tree addresses)
*   a4 - x_lim   (x counter termination)
*   a5 - lpfbits/step 0
*
        link      a6,#LS.LSize      ; locals
        movem.l   d4-d7/a3-a5,-(a7) ; store registers
*
*   Load Bit Buffer
*
        move.l     PS.data(a6),a0    ; a0=&data
        move.l     (a0),d6           ; data=*a0
        move.l     PS.bno(a6),a0     ; a0=&mask
        move.l     (a0),d7           ; mask=*a0
        move.l     PS.ptr(a6),a0     ; a0=&ptr
        move.l     (a0),a0           ; a0=ptr
*
*   Set Up Block Counters
*
        move.l     PS.dst(a6),a1     ; a1=image
        move.l     PS.size_x(a6),d0  ; d0=size_x
        move.l     #16,LS.x_inc(a6) ; save x_inc
        add.l      d0,d0             ; in shorts
        move.l     d0,LS.x_linc(a6)  ; x_linc=1 row
        move.l     PS.size_y(a6),d1  ; d1=size_y
        muls.w     d0,d1             ; d1*=d0 (area)

```

- 673 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```

add.l    a1,d1
move.l   d1,LS.y_lim(a6)
move.l   d0,d2
add.l    d0,d0
move.l   d0,d5
subq.l   #4,d5
move.l   d5,LS.y_blk0(a6)
add.l    d0,d2
add.l    d0,d0
move.l   d0,d4
subq.l   #8,d4
move.l   d4,LS.y_blk1(a6)
add.l    d2,d0
move.l   d0,LS.y_inc(a6)

move.l   PS.norms(a6),a2
move.l   (a2),d2
move.l   4(a2),d3
move.l   8(a2),a5
move.l   PS.lpfbits(a6),d4
swap     d5
move.l   LS.y_blk1(a6),d0
move.w   d0,d5
move.l   PS.sub_tab(a6),a3

@y      move.l   LS.x_linc(a6),a4
        add.l    a1,a4

*
*      Low_Pass
*
@x      move.l   a1,a2
        LPFSTILL #8,d5,d2,d4

*
*      Sub-band gh
*
        bsr      DOSTILL2
        add.l    #20,a3

*
*      Sub-band hg
*
        bsr      DOSTILL2
        add.l    #20,a3

*
*      Sub-band gg
*
        bsr      DOSTILL2
        sub.l    #40,a3

        add.l    #16,a1
        cmp.l    a4,a1
        blt.w    @x
        add.l    LS.y_inc(a6),a1
        cmp.l    LS.y_lim(a6),a1
        blt.w    @y

*      Save Bit Buffer
*
@end    move.l   PS.data(a6),a2
        move.l   d6,(a2)
        move.l   PS.bno(a6),a2
        move.l   d7,(a2)
        move.l   PS.ptr(a6),a2
        move.l   a0,(a2)

```

```

; dl+=image
; y_lim=dl
; d2=d0 (1 row)
; d0*=2 (2 rows)
; copy to d5
; y_blk: subtract x_blk
; save y_blk0
; d2+=d0 (3 rows)
; d0*=2 (4 rows)
; copy to d5
; y_blk: subtract x_blk
; save y_blk1
; d0+=d2 (7 rows)
; y_inc=d0

; GetNorm pointer
; read normal
; read normal 1
; read normal 0
; read lpfbits
; y_blk=00XX
; read y_blk1
; d5=y_blk0/1
; a3=addr

; x_lim=x_linc
; x_lim+=baddr

; caddr=baddr

; (2) addr[0]+=x_inc
; (2) addr[0]-limit?
; (4) if less then loopX
; (2+) addr[0]+=y_inc
; (2+) addr[0]-limit?
; (4) if less then loopY

; spare=&data
; update data
; spare=&bno
; update bno
; spare=&ptr
; update ptr

```

- 674 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

Page 18

```

    movem.l    (a7)+,d4-d7/a3-a5    ; restore registers
    unlk      a6                    ; remove locals
    rts                          ; return

    ENDFUNC
-----
Klics3D2Send  FUNC      EXPORT
*
*   Klics3D2Send(short *dst, long size_x, long size_y, short *norms, unsigned long
*
PS      RECORD      8
dst     DS.L         1
size_x  DS.L         1
size_y  DS.L         1
norms   DS.L         1
ptr     DS.L         1
data    DS.L         1
bno     DS.L         1
sub_tab DS.L         1
        ENDR

LS      RECORD      0,DECR
y_blk0  DS.L         1                ; y inter-block increment    2 rows - 4
y_blk1  DS.L         1                ; y inter-block increment    4 rows - 8
x_inc   DS.L         1                ; x counter increment        16
x_lim   DS.L         1                ; x counter termination      row_start+
x_linc  DS.L         1                ; x termination increment    1 row
y_inc   DS.L         1                ; y counter increment        7 rows
y_lim   DS.L         1                ; y counter termination      area
LSize   EQU          *
        ENDR

*
*   d0 - spare
*   d1 - y_blk1
*   d2 - step 2HH
*   d3 - step 1
*   d4 - step 0
*   d5 - y_blk0
*   d6 - data (bit stream)
*   d7 - bno (bit pointer)
*
*   a0 - ptr (bit buffer)
*   a1 - baddr (block address)
*   a2 - caddr (coeff address)
*   a3 - addrs (tree addresses)
*   a4 - x_lim (x counter termination)
*
        link        a6,#LS.LSize    ; locals
        movem.l     d4-d7/a3-a5,-(a7) ; store registers

*   Load Bit Buffer
*
        move.l      PS.data(a6),a0   ; a0=&data
        move.l      (a0),d6          ; data=*a0
        move.l      PS.bno(a6),a0    ; a0=&mask
        move.l      (a0),d7          ; mask=*a0
        move.l      PS.ptr(a6),a0    ; a0=&ptr
        move.l      (a0),a0          ; a0=ptr

*   Set Up Block Counters
*
        move.l      PS.dst(a6),a1    ; a1=image

```

- 675 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```

        move.l    PS.size_x(a6),d0      ; d0=size_x
        move.l    #16,LS.x_inc(a6)      ; save x_inc
        add.l     d0,d0                  ; in shorts
        move.l    d0,LS.x_linc(a6)      ; x_linc=1 row
        move.l    PS.size_y(a6),d1      ; d1=size_y
        muls.w     d0,d1                  ; d1*=d0 (area)
        add.l     a1,d1                  ; d1+=image
        move.l    d1,LS.y_lim(a6)       ; y_lim=d1
        move.l    d0,d2                  ; d2=d0 (1 row)
        add.l     d0,d0                  ; d0*=2 (2 rows)
        move.l    d0,d5                  ; copy to d5
        subq.l     #4,d5                 ; y_blk: subtract x_blk
        move.l    d5,LS.y_blk0(a6)      ; save y_blk0
        add.l     d0,d2                  ; d2+=d0 (3 rows)
        add.l     d0,d0                  ; d0*=2 (4 rows)
        move.l    d0,d4                  ; copy to d5
        subq.l     #8,d4                 ; y_blk: subtract x_blk
        move.l    d4,LS.y_blk1(a6)      ; save y_blk1
        add.l     d2,d0                  ; d0+=d2 (7 rows)
        move.l    d0,LS.y_inc(a6)       ; y_inc=d0

        move.l    PS.norms(a6),a2        ; GetNorm pointer
        move.l    (a2),d2                ; read normal
        move.l    4(a2),d3               ; read normal 1
        move.l    8(a2),d4               ; read normal 0
        move.l    LS.y_blk1(a6),d1       ; read y_blk1
        move.l    PS.sub_tab(a6),a3      ; a3=addr

@y      move.l    LS.x_linc(a6),a4        ; x_lim=x_linc
        add.l     a1,a4                  ; x_lim+=baddr

*      Low_Pass
*
@x      buf_rinc   a0,d6,d7              ; BUF_INC
        buf_get    d6,d7                ; BUF_GET
        beq.w      @subs                 ; if 0 then process subbands
        move.l     a1,a2                 ; caddr=baddr
        SEND       #8,d1,d2

*      Sub-band gh
*
@subs   bsr        DOSEND2
        add.l      #20,a3

*      Sub-band hg
*
        bsr        DOSEND2
        add.l      #20,a3

*      Sub-band gg
*
        bsr        DOSEND2
        sub.l      #40,a3

        add.l      #16,a1                ; (2) addr[0]+=x_inc
        cmp.l      a4,a1                 ; (2) addr[0]-limit?
        blt.w      @x                    ; (4) if less then loopX
        add.l      LS.y_inc(a6),a1       ; (2+) addr[0]+=y_inc
        cmp.l      LS.y_lim(a6),a1       ; (2+) addr[0]-limit?
        blt.w      @y                    ; (4) if less then loopY

*      Save Bit Buffer

```

- 676 -

Engineering:KlicsCode:CompPict:KlicsDec2.a

```
@end      move.l    PS.data(a6),a2          ; spare=&data
          move.l    d6,(a2)                 ; update data
          move.l    PS.bno(a6),a2          ; spare=&bno
          move.l    d7,(a2)                 ; update bno
          move.l    PS.ptr(a6),a2          ; spare=&ptr
          move.l    a0,(a2)                 ; update ptr
          .
          movem.l   (a7)+,d4-d7/a3-a5      ; restore registers
          unlk      a6                     ; remove locals
          rts                               ; return
*
          ENDFUNC
*-----
          END
```

Engineering:KlicsCode:CompPict:KlicsDec.c

```

/*****
 *
 *  © Copyright 1993 KLICS Limited
 *  All rights reserved.
 *
 *  Written by: Adrian Lewis
 *****/
/*
 *  Importing raw Klics binary files
 *
 *  Stand-alone version
 */

#include "Bits3.h"
#include "Klics.h"
#include "KlicsHeader.h"

typedef char Boolean;

/* If bool true the negate value */
#define negif(bool,value) ((bool)?-(value):(value))

extern void HaarBackward();
extern void Daub4Backward(short *data,int size[2],int oct_src);
extern void TestTopBackward(short *data,int size[2],int oct_src);
extern void TestBackward(short *data,int size[2],int oct_src);
extern void KLICSDCHANNEL(short *dst, long octs, long size_x, long size_y, long
/* Use the bit level file macros (Bits2.h) */
/* buf_use; */

/* Huffman decode a block */
#define HuffDecLev(lev,buf) \
    lev[0]=HuffDecode(buf); \
    lev[1]=HuffDecode(buf); \
    lev[2]=HuffDecode(buf); \
    lev[3]=HuffDecode(buf);

/* Fixed length decode block of integers */
#define IntDecLev(lev,lpf_bits,buf) \
    lev[0]=IntDecode(lpf_bits,buf); \
    lev[1]=IntDecode(lpf_bits,buf); \
    lev[2]=IntDecode(lpf_bits,buf); \
    lev[3]=IntDecode(lpf_bits,buf);

/* Reverse quantize difference block */
#define RevQntDelta(new,old,lev,shift) \
    new[0]=old[0]+(lev[0]<<shift)+(lev[0]!=0?negif(lev[0]<0,(1<<shift)-1>>1):0); \
    new[1]=old[1]+(lev[1]<<shift)+(lev[1]!=0?negif(lev[1]<0,(1<<shift)-1>>1):0); \
    new[2]=old[2]+(lev[2]<<shift)+(lev[2]!=0?negif(lev[2]<0,(1<<shift)-1>>1):0); \
    new[3]=old[3]+(lev[3]<<shift)+(lev[3]!=0?negif(lev[3]<0,(1<<shift)-1>>1):0);

/* Reverse quantize block */
#define RevQnt(new,lev,shift) \
    new[0]=(lev[0]<<shift)+(lev[0]!=0?negif(lev[0]<0,(1<<shift)-1>>1):0); \
    new[1]=(lev[1]<<shift)+(lev[1]!=0?negif(lev[1]<0,(1<<shift)-1>>1):0); \
    new[2]=(lev[2]<<shift)+(lev[2]!=0?negif(lev[2]<0,(1<<shift)-1>>1):0); \
    new[3]=(lev[3]<<shift)+(lev[3]!=0?negif(lev[3]<0,(1<<shift)-1>>1):0);

#define RevQntLPP(new,lev,shift) \
    new[0]=(lev[0]<<shift)+((1<<shift)-1>>1); \
    new[1]=(lev[1]<<shift)+((1<<shift)-1>>1); \
    new[2]=(lev[2]<<shift)+((1<<shift)-1>>1); \

```



- 678 -

Engineering:KlicsCode:CompPict:KlicsDec.c

```

new[3]=(lev[3]<<shift)+((1<<shift)-1>>1);

/* Read a difference block and update memory */
#define DoXferDelta(addr,old,new,lev,dst,shift,mode,oct,nmode,buf) \
    HuffDecLev(lev,buf); \
    RevQntDelta(new,old,lev,shift) \
    PutData(addr,new,dst); \
    mode[oct]=oct==0?M_STOP:nmode;

/* Read a block and update memory */
#define DoXfer(addr,new,lev,dst,shift,mode,oct,nmode,buf) \
    HuffDecLev(lev,buf); \
    RevQnt(new,lev,shift) \
    PutData(addr,new,dst); \
    mode[oct]=oct==0?M_STOP:nmode;

/* Function Name:  IntDecode
 * Description:    Read a integer from bit file
 * Arguments:     bits - bits/integer now signed
 * Returns:       integer value
 */
short  IntDecode(short bits,Buf buf)
{
    int      i, lev=0, mask=1;
    Boolean sign;

    /* Hardware compatatble version */
    buf_rinc(buf);
    sign=buf_get(buf);
    for(i=0;i<bits-1;i++) {
        buf_rinc(buf);
        if (buf_get(buf)) lev != mask;
        mask <=<= 1;
    }
    if (sign) lev= -lev;
    return(lev);
}

/* Function Name:  HuffDecode
 * Description:    Read a Huffman coded integer from bit file
 * Returns:       integer value
 */
short  HuffDecode(Buf buf)
{
    short  lev=0, i;
    Boolean neg;

    /* Hardware compatatble version */
    buf_rinc(buf);
    if (buf_get(buf)) {
        buf_rinc(buf);
        neg=buf_get(buf);
        do {
            buf_rinc(buf);
            lev++;
        } while (lev<7 && !(buf_get(buf)));
        if (!(buf_get(buf))) {
            for(lev=0,i=0;i<7;i++) {
                lev<=<=1;
                buf_rinc(buf);
            }
        }
    }
    if (neg) lev= -lev;
    return(lev);
}

```

- 679 -

Engineering:KlicsCode:CompPict:KlicsDec.c

```

        if (buf_get(buf)) lev++;
    }
    lev+=8;
}
if (neg) lev= -lev;
}
return(lev);
}

/* Function Name: KlicsDChannel
 * Description: Decode a channel of image
 * Arguments: dst - destination memory (and old for videos)
 *            octs, size - octaves of decomposition and image dimensions
 *            normals - HVS weighted normals
 *            lpf_bits - no of bits for LPF integer (image coding only)
 */

void KlicsDecY(short *dst, int octs, int size[2], KlicsFrameHeader *frmh,
KlicsSeqHeader *seqh, Buf buf)
{
    int oct, mask, x, y, sub, step=2<<octs, blk[4], mode[4], base_mode=(frmh->
    Blk addr, new, old, lev;

    for(y=0;y<size[1];y+=step)
    for(x=0;x<size[0];x+=step)
    for(sub=0;sub<4;sub++) {
        mode[oct=octs-1]=base_mode;
        if (sub==0) mode[oct=octs-1] != M_LPF;
        mask=2<<oct;
        do {
            GetAddr(addr,x,y,sub,oct,size,mask);
            switch(mode[oct]) {
                case M_VOID:
                    GetData(addr,old,dst);
                    if (BlkZero(old)) mode[oct]=M_STOP;
                    else { DoZero(addr,dst,mode,oct); }
                    break;
                case M_SENDIM_STILL:
                    buf_rinc(buf);
                    if (buf_get(buf)) {
                        buf_rinc(buf);
                        if (buf_get(buf)) {
                            DoZero(addr,dst,mode,oct);
                        } else {
                            DoXfer(addr,new,lev,dst,frmh->quantizer[octs-oct],mode,oct,M_S
                        }
                    } else
                        mode[oct]=M_STOP;
                    break;
                case M_SEND:
                    buf_rinc(buf);
                    if (buf_get(buf)) {
                        buf_rinc(buf);
                        if (buf_get(buf)) {
                            buf_rinc(buf);
                            if (buf_get(buf)) {
                                GetData(addr,old,dst);
                                DoXferDelta(addr,old,new,lev,dst,frmh->quantizer[octs-oct]
                            } else {
                                DoZero(addr,dst,mode,oct);
                            }
                        }
                    } else {
                        DoXfer(addr,new,lev,dst,frmh->quantizer[octs-oct],mode,oct,M_S

```

- 680 -

Engineering:KlicsCode:CompPict:KlicsDec.c

```

    }
    } else
        mode{oct}=M_STOP;
    break;
case M_STILL:
    buf_rinc(buf);
    if (buf_get(buf)) { DoXfer(addr,new,lev,dst,frmh->quantizer{octs-oct},);
    else mode{oct}=M_STOP;
    break;
case M_LPF|M_STILL:
    IntDecLev(lev,seqh->precision-frmh->quantizer[0],buf);
    RevQntLPF(new,lev,frmh->quantizer[0]);
    PutData(addr,new,dst);
    mode{oct}=M_QUIT;
    break;
case M_LPF|M_SEND:
    buf_rinc(buf);
    if (buf_get(buf)) {
        GetData(addr,old,dst);
        HuffDecLev(lev,buf);
        RevQntDelta(new,old,lev,frmh->quantizer[0]);
        PutData(addr,new,dst);
    }
    mode{oct}=M_QUIT;
    break;
}
switch(mode{oct}) {
case M_STOP:
    StopCounters(mode,oct,mask,blk,x,y,octs);
    break;
case M_QUIT:
    break;
default:
    DownCounters(mode,oct,mask,blk);
    break;
}
} while (mode{oct}!=M_QUIT);
}
}

void KlicsDecUV(short *dst, int octs, int size[2], KlicsFrameHeader *frmh,
KlicsSeqHeader *seqh, Buf buf)
{
    int oct, mask, x, y, X, Y, sub, step=4<<octs, blk[4], mode[4], base_mode=;
    Blk addr, new, old, lev;

    for(Y=0;Y<size[1];Y+=step)
    for(X=0;X<size[0];X+=step)
    for(y=Y;y<size[1] && y<Y+step;y+=step>>1)
    for(x=X;x<size[0] && x<X+step;x+=step>>1)
    for(sub=0;sub<4;sub++) {
        mode{oct=octs-1}=base_mode;
        if (sub==0) mode{oct=octs-1} != M_LPF;
        mask=2<<oct;
        do {
            GetAddr(addr,x,y,sub,oct,size,mask);
            switch(mode{oct}) {
            case M_VOID:
                GetData(addr,old,dst);
                if (BlkZero(old)) mode{oct}=M_STOP;
                else { DoZero(addr,dst,mode{oct}); }
                break;
            case M_SEND|M_STILL:

```

- 681 -

Engineering:KlicsCode:CompPict:KlicsDec.c

```

    buf_rinc(buf);
    if (buf_get(buf)) {
        buf_rinc(buf);
        if (buf_get(buf)) {
            DoZero(addr,dst,mode,oct);
        } else {
            DoXfer(addr,new,lev,dst,frmh->quantizer{octs-oct},mode,oct,M_S
        )
    } else
        mode[oct]=M_STOP;
    break;
case M_SEND:
    buf_rinc(buf);
    if (buf_get(buf)) {
        buf_rinc(buf);
        if (buf_get(buf)) {
            buf_rinc(buf);
            if (buf_get(buf)) {
                GetData(addr,old,dst);
                DoXferDelta(addr,old,new,lev,dst,frmh->quantizer{octs-oct})
            } else {
                DoZero(addr,dst,mode,oct);
            }
        } else {
            DoXfer(addr,new,lev,dst,frmh->quantizer{octs-oct},mode,oct,M_S
        )
    } else
        mode[oct]=M_STOP;
    break;
case M_STILL:
    buf_rinc(buf);
    if (buf_get(buf)) { DoXfer(addr,new,lev,dst,frmh->quantizer{octs-oct},
    else mode[oct]=M_STOP;
    break;
case M_LPF|M_STILL:
    IntDecLev(lev,seqh->precision-frmh->quantizer{0},buf);
    RevQntLPF(new,lev,frmh->quantizer{0});
    PutData(addr,new,dst);
    mode[oct]=M_QUIT;
    break;
case M_LPF|M_SEND:
    buf_rinc(buf);
    if (buf_get(buf)) {
        GetData(addr,old,dst);
        HuffDecLev(lev,buf);
        RevQntDelta(new,old,lev,frmh->quantizer{0});
        PutData(addr,new,dst);
    }
    mode[oct]=M_QUIT;
    break;
}
switch(mode[oct]) {
case M_STOP:
    StopCounters(mode,oct,mask,blk,x,y,octs);
    break;
case M_QUIT:
    break;
default:
    DownCounters(mode,oct,mask,blk);
    break;
}
} while (mode[oct]!=M_QUIT);
}

```

- 682 -

Engineering:KlicsCode:CompPict:KlicsDec.c

```

)

/* Function Name:  KlicsDecode
 * Description:    Decode a frame to YUV (de)transformed image
 * Arguments:     src - destination result
 *               dst - transformed destination memory (and old for videos)
 * Returns:       whether this frame was skipped
 */

extern void KLCOPY(short *dst, short *src, long area);
extern void KLHALF(short *dst, short *src, long size_0, long size_1);
extern void KLICS3D2SEND(short *dst, long size_x, long size_y, short norms[4]);
extern void KLICS2D1STILL(short *dst, long size_x, long size_y, long lpfbits,
extern void KLICS3D2STILL(short *dst, long size_x, long size_y, long lpfbits,
extern void KLICS2D1SEND(short *dst, long size_x, long size_y, short norms[4]);

#define flag_tree 0x1
#define flag_wave 0x2

void KlicsDecode(short *src[3], short *dst[3], KlicsSeqHeader *seqh, KlicsFrameH
{
    long channel, i;
    short norms[4][2];
    unsigned long sync1, sync2;

    for(i=0; i<4; i++) {
        norms[i][0] = (1<<(frmh->quantizer[i]-1))-1;
        norms[i][1] = frmh->quantizer[i];
    }
    buf_rinit(buf);
    if (0 != (flags & flag_tree)) {
        sync1 = GetTimerValue(&sync1);
        for(channel=0; channel<seqh->channels; channel++) {
            int size[2] = {seqh->sequence_size[0]>>(channel==0?0:seqh->sub_sampl
                        seqh->sequence_size[1]>>(channel==0?0:seqh->sub_sample[1])
                        tree_size[2] = {size[0]>>scale[0], size[1]>>scale[0]},
                        octs = seqh->octaves[channel==0?0:1];

#ifdef HQ
            if (0 != (frmh->flags & KFH_INTRA))
                KLZERO(dst[channel], tree_size[0]*tree_size[1]);
            /* KLICSDCHANNEL(dst[channel], octs-1, tree_size[0], tree_size[1], (long) (seq
            if (channel==0) KlicsDecY(dst[channel], octs, tree_size, frmh, seqh, buf);
            else KlicsDecUV(dst[channel], octs, tree_size, frmh, seqh, buf);
#else
            long sub_tab[15] = {4, 2, 10, 2+8*tree_size[0], 10+8*tree_size[0],
                                4*tree_size[0], 2*tree_size[0], 8+2*tree_size[0], 10*tree_siz
                                4+4*tree_size[0], 2+2*tree_size[0], 10+2*tree_size[0], 2+10*t

            if (0 != (frmh->flags & KFH_INTRA)) {
                KLZERO(dst[channel], tree_size[0]*tree_size[1]);
                if (octs==3)
                    KLICS3D2STILL(dst[channel], tree_size[0], tree_size[1], (long) (se
                else
                    KLICS2D1STILL(dst[channel], tree_size[0], tree_size[1], (long) (se
            ) else
                if (octs==3)
                    KLICS3D2SEND(dst[channel], tree_size[0], tree_size[1], &norms, &bu
                else
                    KLICS2D1SEND(dst[channel], tree_size[0], tree_size[1], &norms, &bu
#endif
        }
        sync2 = GetTimerValue(&sync2);

```

- 683 -

Engineering:KlicsCode:CompPict:KlicsDec.c

```

    *tree=sync2-sync1;
}
if (0!=(flags&flag_wave)) {
    sync1=GetTimerValue(&sync1);
    for(channel=0;channel<seqh->channels;channel++) {
        int    size[2]={seqh->sequence_size[0]>>(channel==0?0:seqh->sub_sampl
                    seqh->sequence_size[1]>>(channel==0?0:seqh->sub_sample[1])
        wave_size[2]={size[0]>>scale[1],size[1]>>scale[1]},
        octs=seqh->octaves[channel==0?0:1];

        switch(seqh->wavelet) {
        case WT_Haar:
            if (scale[1]>scale[0])
                KLHALF(dst[channel],src[channel],wave_size[0],wave_size[1]);
            else
                KLCOPY(dst[channel],src[channel],wave_size[0]*wave_size[1]);
            HaarBackward(src[channel],wave_size,octs-scale[1]);
            break;
        case WT_Daub4:
            if (scale[0]==0) {
                if (scale[1]>scale[0])
                    KLHALF(dst[channel],src[channel],wave_size[0],wave_size[1]
                else
                    KLCOPY(dst[channel],src[channel],wave_size[0]*wave_size[1]
                Daub4Backward(src[channel],wave_size,octs-scale[1]);
            } else
                if (channel==0) {
                    KLCOPY(dst[channel],src[channel],wave_size[0]*wave_size[1]
                    Backward3511(src[channel],wave_size,octs-scale[1]);
                } else
                    TOPBWD(dst[channel],src[channel],wave_size[0],wave_size[1]
            break;
        }
    }
    sync2=GetTimerValue(&sync2);
    *wave=sync2-sync1;
}
}

```

- 684 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

/*****
 *
 *  © Copyright 1993 KLICS Limited
 *  All rights reserved.
 *
 *  Written by: Adrian Lewis
 *
 *****/
/*
 *  Klics Codec
 */

#include "ImageCodec.h"
#include <FixMath.h>
#include <Errors.h>
#include <Packages.h>

#ifdef PERFORMANCE
    #include <Perf.h>
    extern TP2PerfGlobals ThePGlobals;
#endif

#ifdef DEBUG
    #define DebugMsg(val)    DebugStr(val)
#else
    #define DebugMsg(val)
#endif

#define WT_Haar  0
#define WT_Daub4 1

#define None      0
#define Use8      1
#define Use16     2
#define Use32     3
#define UseF32    4

/* Version information */

#define KLICS_CODEC_REV      1
#define codecInterfaceVersion 1 /* high word returned in component GetVersion */

#define klicsCodecFormatName "Klics"
#define klicsCodecFormatType 'klic'

pascal ComponentResult
KlicsCodec(ComponentParameters *params, char **storage);

pascal ComponentResult
KLOpenCodec(ComponentInstance self);

pascal ComponentResult
KLCloseCodec(Handle storage, ComponentInstance self);

pascal ComponentResult
KLCanDoSelector(short selector);

pascal ComponentResult
KLGetVersion();

pascal ComponentResult
KLGetCodecInfo(Handle storage, CodecInfo *info);

```

- 685 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

pascal ComponentResult
KLGetMaxCompressionSize(Handle storage, PixmapHandle src, const Rect *srcRect, short
    CodecQ quality, long *size);

pascal ComponentResult
KLGetCompressedImageSize(Handle storage, ImageDescriptionHandle desc, Ptr data, long
    DataProcRecordPtr dataProc, long *size);

pascal ComponentResult
KLPreCompress(Handle storage, register CodecCompressParams *p);

pascal long
KLPreDecompress(Handle storage, register CodecDecompressParams *p);

pascal long
KLBandDecompress(Handle storage, register CodecDecompressParams *p);

pascal long
KLBandCompress(Handle storage, register CodecCompressParams *p);

pascal ComponentResult
KLGetCompressionTime(Handle storage, PixmapHandle src, const Rect *srcRect, short dep
    CodecQ *spatialQuality, CodecQ *temporalQuality, unsigned long *time);

/* Function: KlicsCodec
 * Description: KlicsCodec main dispatcher
 */

#ifdef DECODER
pascal ComponentResult
KlicsDecoder(ComponentParameters *params, char **storage)
#else
#ifdef ENCODER
pascal ComponentResult
KlicsEncoder(ComponentParameters *params, char **storage)
#else
pascal ComponentResult
KlicsCodec(ComponentParameters *params, char **storage)
#endif
#endif
{
    OSErr err;

    switch ( params->what ) {
    case kComponentOpenSelect:
        err=CallComponentFunction(params, (ComponentFunction) KLOpenCodec); break;

    case kComponentCloseSelect:
        err=CallComponentFunctionWithStorage(storage, params, (ComponentFunction) KLC

    case kComponentCanDoSelect:
        err=CallComponentFunction(params, (ComponentFunction) KLCanDoSelector); brea

    case kComponentVersionSelect :
        err=CallComponentFunction(params, (ComponentFunction) KLGetVersion); break;

#ifdef DECODER
    case codecPreCompress:
    case codecBandCompress:
        err=codecUnimpErr; break;
#else
    case codecPreCompress:

```



- 686 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

    err=CallComponentFunctionWithStorage(storage,params,(ComponentFunction)KLP
    case codecBandCompress:
        err=CallComponentFunctionWithStorage(storage,params,(ComponentFunction)KLB
#endif
#ifdef ENCODER
    case codecPreDecompress:
    case codecBandDecompress:
        err=codecUnimpErr; break;
#else
    case codecPreDecompress:
        err=CallComponentFunctionWithStorage(storage,params,(ComponentFunction)KLP

    case codecBandDecompress:
        err=CallComponentFunctionWithStorage(storage,params,(ComponentFunction)KLB
#endif
    case codecCDSequenceBusy:
        err=0; break; /* our codec is never asynchronously busy

    case codecGetCodecInfo:
        err=CallComponentFunctionWithStorage(storage,params,(ComponentFunction)KLG

    case codecGetCompressedImageSize:
        err=CallComponentFunctionWithStorage(storage,params,(ComponentFunction)KLG

    case codecGetMaxCompressionSize:
        err=CallComponentFunctionWithStorage(storage,params,(ComponentFunction)KLG

    case codecGetCompressionTime:
        err=CallComponentFunctionWithStorage(storage,params,(ComponentFunction)KLG

    case codecGetSimilarity:
        err=codecUnimpErr; break;

    case codecTrimImage:
        err=codecUnimpErr; break;

    default:
        err=paramErr; break;
    )
    if (err!=noErr)
        DebugMsg("\pCodec Error");
    return(err);
}

#include <Memory.h>
#include <Resources.h>
#include <OSUtils.h>
#include <SysEqu.h>

#include <StdIO.h>
#include <Time.h>

#include <Strings.h>
#include <String.h>
#include "Bits3.h"
#include "KlicsHeader.h"
#include "KlicsEncode.h"

void DebugString(char *string)
{
    DebugStr(string);
}

```

- 687 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

extern short  gResRef;

typedef struct (
    CodecInfo  **info;
    Ptr        tab[4];
    short      use[4];
) SharedGlobals;

typedef struct (
    KlicsERec  kle;
    short      *src[3];
    short      *dst[3];
    Ptr        pixmap;
    long       size;
    long       using;
    long       scale[3];
    unsigned long prev_frame;
    unsigned long real_frame;
    unsigned long dpy_frame;
    unsigned long run_frame;
    unsigned long sys_time;
    unsigned long tree_time;
    unsigned long wave_time;
    unsigned long dpy_time;
    unsigned long run_time;
    unsigned long key_time;
    unsigned long sync_time;
    Boolean out[15];
    SharedGlobals *sharedGlob;
) Globals;

/* Scaling scenarios: Tree Wave Out
 *
 * 1 1 0: Internal calculations are Quarter size, output Original size (interpo
 * 1 1 1: Internal calculations are Quarter size, output Quarter size
 * 0 1 1: Internal calculations are Original size, output Quarter size
 * 0 0 0: Internal calculations are Original size, output Original size
 * 0 0 -1: Internal calculations are Original size, output Double size
 */

void  KLDeallocate(Globals **glob);

/* Klics Function Definitions */

extern int  KlicsEncode(short *src[3], short *dst[3], KlicsE kle);
extern Boolean KlicsDecode(short *src[3], short *dst[3], KlicsSeqHeader *seqh, Kli
    long mode, long scale[3], unsigned long *tree, unsigned long *wave);

/*****
 *
 *  Memory allocation/deallocation routines
 *
 *****/

OSErr
MemoryError()
{
    OSErr  theErr;

#ifdef DEBUG
    if (0!==(theErr=MemError()))
        DebugStr("\pMemoryError");

```

- 688 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

#endif
    return(theErr);
}

OSErr
FreePtr(Ptr *ptr)
{
    OSErr theErr=0;

    if (*ptr!=nil) {
        DisposePtr(*ptr);
        *ptr=nil;
        theErr=MemoryError();
    }
    return(theErr);
}

#define FreePointer(handle,err) \
    if (noErr!=(err=FreePtr((Ptr*)&handle))) return(err)

extern OSErr Colour8(Ptr *);
extern OSErr Colour16(Ptr *);
extern OSErr UV32Table(Ptr *);
extern OSErr RGBTable(Ptr *);

OSErr
KLGetTab(Globals **glob,long new)
{
    OSErr theErr=0;
    SharedGlobals *sGlob=(*glob)->sharedGlob;
    long old=(*glob)->using;

    if (old!=new) {
        if (old!=None) {
            sGlob->use[old-1]--;
            if (sGlob->use[old-1]==0) {
                FreePointer(sGlob->tab[old-1],theErr);
            }
        }

        if (new!=None) {
            if (sGlob->use[new-1]==0)
                switch(new) {
#ifdef ENCODER
                    case Use8:
                        if (noErr!=(theErr=Colour8(&sGlob->tab[new-1])))
                            return(theErr);
                        break;
                    case Use16:
                        if (noErr!=(theErr=Colour16(&sGlob->tab[new-1])))
                            return(theErr);
                        break;
                    case Use32:
                        if (noErr!=(theErr=UV32Table(&sGlob->tab[new-1])))
                            return(theErr);
                        break;
#endif
#ifdef DECODER
                    case UseF32:
                        if (noErr!=(theErr=RGBTable(&sGlob->tab[new-1])))
                            return(theErr);
                        break;
#endif
                }
        }
    }
}

```

- 689 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

#endif
    }
    (*glob)->using=new;
    sGlob->use[new-1]++;
}
return(theErr);
}

OSErr
KLFree(Globals **glob)
{
    OSErr theErr=0;

    FreePointer((*glob)->src[0],theErr);
    FreePointer((*glob)->dst[0],theErr);
    FreePointer((*glob)->pixmap,theErr);
    (*glob)->size=0;
    return(theErr);
}

#define NewPointer(ptr,type,size) \
    saveZone=GetZone(); \
    SetZone(SystemZone()); \
    if (nil==(ptr)=(type)NewPtr(size)) { \
        SetZone(ApplicZone()); \
        if (nil==(ptr)=(type)NewPtr(size)) { \
            SetZone(saveZone); \
            return(MemoryError()); \
        } \
    } \
    SetZone(saveZone);

ComponentResult
KLMalloc(Globals **glob, short height, short width, long pixelSize)
{
    long    ysize,uvsize;
    THz     saveZone;

    ysize=(long)height * (long)width * (long)sizeof(short);
    uvsize = ysize>>2;

    if ((*glob)->size != ysize) {
        KLFree(glob);
        (*glob)->size = ysize;
        (*glob)->prev_frame=-1; /* frame doesn't contain valid data */

        /* Keep Src and Dst separate because of their large sizes */

        ysize=(long)height * (long)width * (long)sizeof(short) >> 2*(*glob)->scale
        uvsize = ysize>>2;
        NewPointer((*glob)->src[0],short *,ysize+uvsize+uvsize+16);
        (*glob)->src[1] = (short *)(((long)(*glob)->src[0] + ysize + 3L) & 0xFFFFF
        (*glob)->src[2] = (short *)(((long)(*glob)->src[1] + uvsize + 3L) & 0xFFFFF

        ysize=(long)height * (long)width * (long)sizeof(short) >> 2*(*glob)->scale
        uvsize = ysize>>2;
        NewPointer((*glob)->dst[0],short *,ysize+uvsize+uvsize+16);
        (*glob)->dst[1] = (short *)(((long)(*glob)->dst[0] + ysize + 3L) & 0xFFFFF
        (*glob)->dst[2] = (short *)(((long)(*glob)->dst[1] + uvsize + 3L) & 0xFFFFF

```

- 690 -

```

Engineering:KlicsCode:CompPict:KlicsCodec.c

    NewPointer((*glob)->pixmap.Ptr,pixelSize/8*height*width<<1);
}
return(noErr);
}

OSErr
ResourceError()
{
    OSErr    theErr;

#ifdef DEBUG
    if (0!=(theErr=ResError()))
        DebugStr("\pResourceError");
#endif
    return(theErr);
}

#ifdef COMPONENT
#define ResErr(resfile,err) \
    if (0!=(err=ResourceError())) { \
        if (resfile!=0) CloseComponentResFile(resfile); \
        return(err); \
    }
#else
#define ResErr(resfile,err) \
    if (0!=(err=ResourceError())) { \
        return(err); \
    }
#endif

ComponentResult
KLOpenInfoRes(ComponentInstance self, Handle *info)
{
    #pragma unused(self)
    short    resFile=0;
    OSErr    theErr=noErr;

    if (*info) {
        DisposHandle(*info);
        *info=nil;
    }

#ifdef COMPONENT
    resFile=OpenComponentResFile((Component)self);
    ResErr(resFile,theErr);
#else
    UseResFile(gResRef);
#endif
    *info=Get1Resource(codecInfoResourceType,128);
    *info=Get1Resource(codecInfoResourceType,129);
    ResErr(resFile,theErr);
    LoadResource(*info);
    ResErr(resFile,theErr);
    DetachResource(*info);
#ifdef COMPONENT
    CloseComponentResFile(resFile);
#endif
    return(theErr);
}

pascal ComponentResult
KLOpenCodec(ComponentInstance self)
{
    Globals        **glob;

```

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

SharedGlobals  *sGlob;
THz            saveZone;
Boolean        inAppHeap;
ComponentResult result = noErr;
short          resFile=CurResFile();

DebugMsg("\pOpen Codec - begin");
if ( (glob = (Globals **)NewHandleClear(sizeof(Globals))) == nil ) {
    return(MemoryError());
} else HNoPurge((Handle)glob);
SetComponentInstanceStorage(self, (Handle)glob);

saveZone = GetZone();
inAppHeap = ( GetComponentInstanceA5(self) != 0 );
if ( !inAppHeap )
    SetZone(SystemZone());
if ( (sGlob=(SharedGlobals*)GetComponentRefcon((Component)self)) == nil ) {
    if ( (sGlob = (SharedGlobals*)NewPtrClear(sizeof(SharedGlobals))) == nil ) {
        result=MemoryError();
        goto obail;
    }
    SetComponentRefcon((Component)self, (long)sGlob);
}

(*glob)->sharedGlob = sGlob;    // keep this around where it's easy to get at
if ( sGlob->info == nil || *(Handle)sGlob->info == nil ) {
    result=KLOpenInfoRes(self, &(Handle)(sGlob->info));
    HNoPurge((Handle)sGlob->info);
}

obail:
SetZone(saveZone);
if ( result != noErr && sGlob != nil ) {
    if ( sGlob->info )
        DisposHandle((Handle)sGlob->info);
    DisposPtr((Ptr)sGlob);
    SetComponentRefcon((Component)self, (long)nil);
}
(*glob)->size=0;
DebugMsg("\pOpen Codec - end");
return(result);
}

pascal ComponentResult
KLCloseCodec(Handle storage, ComponentInstance self)
{
    SharedGlobals  *sGlob;
    Globals        **glob = (Globals **)storage;

    DebugMsg("\pClose Codec - begin");
    HLock(storage);
    if ( glob ) {
        KLFree(glob);
        KLGetTab(glob, None);
        if (CountComponentInstances((Component)self) == 1) {
            if ( (sGlob=(SharedGlobals*))(*glob)->sharedGlob) != nil ) {
                if ( sGlob->info )
                    HPurge((Handle)sGlob->info);
            }
        }
        DisposHandle((Handle)glob);
    }
}

```

```

Engineering:KlicsCode:CompPict:KlicsCodec.c

    height = 120;
    )
    if (time)
        *time = (width * height * 1L);

    if (spatialQuality && *spatialQuality==codecLosslessQuality)
        *spatialQuality = codecMaxQuality;

    if (temporalQuality && *temporalQuality==codecLosslessQuality)
        *temporalQuality = codecMaxQuality;

    return(noErr);
}

/*
 * Extends dimensions to make a multiples of 32x16
 */

#define KLEExtendWidth(dim)  31-(dim-1&31)
#define KLEExtendHeight(dim) 15-(dim-1&15)

pascal ComponentResult
KLGetMaxCompressionSize(Handle storage, PixMapHandle src, const Rect *srcRect, short
    CodecQ quality, long *size)
{
    #pragma unused(storage, src, depth, quality)
    short width = srcRect->right - srcRect->left;
    short height = srcRect->bottom - srcRect->top;

    /* test by just doing RGB storage */

    *size = 3 * (width+KLEExtendWidth(width)) * (height+KLEExtendHeight(height));
    return(noErr);
}

pascal ComponentResult
KLGetCompressedImageSize(Handle storage, ImageDescriptionHandle desc, Ptr data, long
    DataProcRecordPtr dataProc, long *size)
{
    #pragma unused(storage, dataSize, dataProc, desc)
    short   frmh_size;
    long    data_size;

    if ( size == nil ) {
        return(paramErr);
    }
    frmh_size=((KlicsHeader *)data)->description_length;
    data_size=((KlicsFrameHeader *)data)->length;
    *size=(long)frmh_size+data_size;
    return(noErr);
}

void    KLSetup(Boolean still, short width, short height, CodecQ space, CodecQ tem
{
    kle->seqh.head.description_length=sizeof(KlicsSeqHeader);
    kle->seqh.head.version_number[0]=0;
    kle->seqh.head.version_number[1]=1;
    kle->seqh.sequence_size[0]=width;
    kle->seqh.sequence_size[1]=height;
    kle->seqh.sequence_size[2]=0;
    kle->seqh.sub_sample[0]=1;
    kle->seqh.sub_sample[1]=1;
    kle->seqh.wavelet=WT_Daub4;
}

```

- 693 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

kle->seqh.precision=10;
kle->seqh.octaves[0]=3;
kle->seqh.octaves[1]=2;

kle->frmh.head.description_length=sizeof(KlicsFrameHeader);
kle->frmh.head.version_number[0]=0;
kle->frmh.head.version_number[1]=1;

kle->encd.bpf_in=(2133+temp*160)/8;          /* High = 64000 bits/frame, Poor = 1
kle->encd.bpf_out=kle->encd.bpf_in;
kle->encd.buf_size=kle->encd.bpf_in*4;

kle->encd.quant=16-(space*15)/1023;
kle->encd.thresh=1.0;
kle->encd.compare=1.0;
kle->encd.base[0]=0.10;
kle->encd.base[1]=0.10;
kle->encd.base[2]=0.20;
kle->encd.base[3]=0.50;
kle->encd.base[4]=1.00;
kle->encd.intra=still;
kle->encd.auto_q=true;
kle->encd.buf_sw=true;
kle->encd.prevquact=1;
kle->encd.prevbytes=13;
}

#ifdef DECODER
pascal ComponentResult
KLPreCompress(Handle storage,register CodecCompressParams *p)
(
    ComponentResult    result;
    CodecCapabilities  *capabilities = p->capabilities;
    short              width=(p->imageDescription)->width+(capabilities->extendw
    short              height=(p->imageDescription)->height+(capabilities->exten
    Globals             **glob=(Globals **)storage;
    KlicsE              kle=&(*glob)->kle;
    Handle              ext=NewHandle(sizeof(KlicsSeqHeader));

    DebugMsg("\pKLPreCompress");
    HLock(storage);
    if (MemError()!=noErr) return(MemError());
    switch ( (p->imageDescription)->depth ) {
        case 24:
            capabilities->wantedPixelSize = 32;
            kle->seqh.channels=3;
            if (noErr!=(result=KLGetTab(glob,UseF32)))
                return(result);
            break;
        default:
            return(codecConditionErr);
            break;
    }

    /* Going to use 3 octaves for Y and 2 for UV so the image must be a multiple o
    capabilities->bandMin = height;
    capabilities->bandInc = capabilities->bandMin;

    capabilities->flags=codecCanCopyPrevComp|codecCanCopyPrev;

    (*glob)->scale[0]=0;
    (*glob)->scale[1]=0;

```



- 694 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

(*glob)->scale[2]=0;

if (noErr!=(result=KLMalloc(glob.height,width,0))) return result;
KLSetup(p->sequenceID==0,width,height,(*p->imageDescription)->spatialQuality,(
BlockMove((Ptr)&kle->seqh,*ext,sizeof(KlicsSeqHeader));
if (noErr!=(result=SetImageDescriptionExtension(p->imageDescription,ext,klicsC
return result;

HUnlock(storage);
DebugMsg("\pKLPreCompress success");
return(result);
)
#endif

#ifdef ENCODER
pascal long
KLPreDecompress(Handle storage,register CodecDecompressParams *p)
(
    ComponentResult      result;
    CodecCapabilities    *capabilities = p->capabilities;
    Rect                 dRect = p->srcRect;
    long                 width;
    long                 height;
    long                 channels;
    Globals               **glob=(Globals **)storage;
    KlicsE                kle;
    Handle                ext;
    OSErr                err;

    DebugMsg("\pKLPreDecompress");
    if ( !TransformRect(p->matrix,&dRect,nil) )
        return(codecConditionErr);

    HLock(storage);
    kle=&(*glob)->kle;
    switch ( (*p->imageDescription)->depth ) {
        case 24:
            switch(p->dstPixMap.pixelSize) {
                case 32:
                    capabilities->wantedPixelSize = 32;
                    if (p->conditionFlags&codecConditionNewDepth) {
                        if (noErr!=(err=KLGetTab(glob,Use32)))
                            return(err);
                    }
                    break;
                case 16:
                    capabilities->wantedPixelSize = 16;
                    if (p->conditionFlags&codecConditionNewDepth) {
                        if (noErr!=(err=KLGetTab(glob,Use16)))
                            return(err);
                    }
                    break;
                case 8:
                    capabilities->wantedPixelSize = 8;
                    if (p->conditionFlags&codecConditionNewDepth) {
                        if (noErr!=(err=KLGetTab(glob,Use8)))
                            return(err);
                    }
                    break;
            }
        channels=3;
        break;
    }

```

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

    default:
        return(codecConditionErr);
        break;
    }

    if (noErr!=(result=GetImageDescriptionExtension(p->imageDescription,&ext,klics
    BlockMove(*ext,(Ptr)&kle->seqh,sizeof(KlicsSeqHeader)));
    if (channels==1) kle->seqh.channels=1;

    /* Going to use 3 octaves for Y and 2 for UV so the image must be a multiple o

#ifdef HQ
    (*glob)->scale[0]=0; /* Tree scale */
#else
    (*glob)->scale[0]=1; /* Tree scale */
#endif
    width=kle->seqh.sequence_size[0];
    height=kle->seqh.sequence_size[1];

    switch((*glob)->scale[0]) {
    case 1: /* Quarter size internal */
        (*glob)->scale[1]=1;
        if (p->matrix->matrix[0][0]==p->matrix->matrix[1][1])
            switch(p->matrix->matrix[0][0]) {
            case 32768:
                capabilities->flags=codecCanScale;
                capabilities->extendWidth=width/2-dRect.right;
                capabilities->extendHeight=height/2-dRect.bottom;
                (*glob)->scale[2]=1;
                break;
            case 65536:
                capabilities->extendWidth=width-dRect.right;
                capabilities->extendHeight=height-dRect.bottom;
                (*glob)->scale[2]=0;
                break;
            default:
                capabilities->extendWidth=0;
                capabilities->extendHeight=0;
                (*glob)->scale[2]=0;
                break;
            }
        else {
            capabilities->extendWidth=0;
            capabilities->extendHeight=0;
            (*glob)->scale[2]=0;
        }
        break;
    case 0: /* Full size internal */
        if (p->matrix->matrix[0][0]==p->matrix->matrix[1][1])
            switch(p->matrix->matrix[0][0]) {
            case 32768:
                capabilities->flags=codecCanScale;
                capabilities->extendWidth=width/2-dRect.right;
                capabilities->extendHeight=height/2-dRect.bottom;
                (*glob)->scale[1]=1;
                (*glob)->scale[2]=1;
                break;
            case 131072:
                capabilities->flags=codecCanScale;
                capabilities->extendWidth=width*2-dRect.right;
                capabilities->extendHeight=height*2-dRect.bottom;
                (*glob)->scale[1]=0;
                (*glob)->scale[2]=-1;

```

- 696 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

        break;
    case 65536:
        capabilities->extendWidth=width-dRect.right;
        capabilities->extendHeight=height-dRect.bottom;
        (*glob)->scale[1]=0;
        (*glob)->scale[2]=0;
        break;
    default:
        capabilities->extendWidth=0;
        capabilities->extendHeight=0;
        (*glob)->scale[1]=0;
        (*glob)->scale[2]=0;
    }
    else {
        capabilities->extendWidth=0;
        capabilities->extendHeight=0;
        (*glob)->scale[1]=0;
        (*glob)->scale[2]=0;
    }
    break;
}

capabilities->bandMin = height;
capabilities->bandInc = capabilities->bandMin;
capabilities->flags|=codecCanCopyPrev|codecCanCopyPrevComp|codecCanRemapColor;

if (noErr!=(result=KLMalloc(glob,height,width,capabilities->wantedPixelSize)))
    HUnlock(storage);
DebugMsg("\pKLPreDecompress success");
return(result);
}
#endif

/* Test Versions in C - Colour.c */
void RGB2YUV32(long *pixmap, short *Yc, short *Uc, short *Vc, int area, int wid
void YUV2RGB32(long *pixmap, short *Yc, short *Uc, short *Vc, int area, int wid
void YUV2RGB32x2(Ptr table,long *pixmap, short *Yc, short *Uc, short *Vc, int a

/* Assembler versions - Colour.a */
OUT32X2(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,l
OUT32X2D(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,
OUT32(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,lon
OUT32D(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,lon
OUT8X2(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,lon
OUT8(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,lon
OUT16X2(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,l
OUT16(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,lon
IN32(Ptr table,long *pixmap,short *Y,short *U,short *V,long width,long height,long

/* Assembler versions - Color2.a */
void RGB2YUV2(long *pixmap, short *Yc, short *Uc, short *Vc, int area, int widt
void YUV2RGB2(long *pixmap, short *Yc, short *Uc, short *Vc, int area, int widt
void YUV2RGB3(long *pixmap, short *Yc, short *Uc, short *Vc, int area, int widt
void GREY2Y(long *pixmap, short *Yc, int area, int width, int cols);
void Y2GREY(long *pixmap, short *Yc, int lines, int width, int cols);
void Y2GGG(long *pixmap, short *Yc, int lines, int width, int cols);

/*YUV2RGB4((*glob)->Table,pixmap,src[0],src[1],src[2],cols*(*desc)->height>>scale,
YUV2RGB5((*glob)->Table,pixmap,src[0],src[1],src[2],cols*(*desc)->height,width>>sc

#pragma parameter _D0 MicroSeconds

```

- 697 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

pascal unsigned long MicroSeconds(void) = (0x4EB0, 0x81E1, 0x64C);

unsigned long GetTimerValue(unsigned long *TimerRes)
{
    *TimerRes = CLOCKS_PER_SEC;
    return(MicroSeconds());
}

#ifdef DECODER
pascal long
KLBandCompress(Handle storage,register CodecCompressParams *p)
{
    #pragma unused(storage)
    Globals **glob = (Globals **)storage;
    ImageDescription **desc = p->imageDescription;
    char *baseAddr;
    short rowBytes;
    Rect sRect;
    long offsetH,offsetV;
    OSErr result = noErr;
    short *src[3],*dst[3];
    long *pixmap;
    int width=(*desc)->width+KLExtendWidth((*desc)->width);
    int height=(*desc)->height+KLExtendHeight((*desc)->height);
    int hwidth=width>>1,hheight=height>>1;
    int bytes;
    KlicsE kle;
    char mmuMode=1;
    char intra[]="\pENC:Intra-mode", inter[]="\pENC:Inter-mode";
    SharedGlobals *sGlob;

    #ifdef PERFORMANCE
        (void)PerfControl(ThePGlobals,true);
    #endif

    DebugMsg("\pBandCompress");
    HLock((Handle)glob);
    kle=&(*glob)->kle;
    sGlob=(*glob)->sharedGlob;

    rowBytes = p->srcPixmap.rowBytes & 0x3fff;
    sRect = p->srcPixmap.bounds;
    switch ( p->srcPixmap.pixelSize ) {
    case 32:
        offsetH = sRect.left<<2;
        break;
    case 16:
        offsetH = sRect.left<<1;
        break;
    case 8:
        offsetH = sRect.left;
        break;
    default:
        result = codecErr;
        DebugMsg("\pError");
        goto bail;
    }
    offsetV = sRect.top * rowBytes;
    baseAddr = p->srcPixmap.baseAddr + offsetH + offsetV;
    pixmap=(long *)baseAddr;

    /* FSMakeFSSpec(0,0,"pUser:crap001",&fsspec);
    FSpCreate(&fsspec,"????","????",-1);

```

- 698 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

FSpOpenDF(&fsspec,fsWrPerm,&fileRefNum);
area=height*rowBytes;
FSWrite(fileRefNum,&area,(long*)pixmap);
FSClose(fileRefNum);*/

src[0]=(*glob)->src[0]; src[1]=(*glob)->src[1]; src[2]=(*glob)->src[2];
dst[0]=(*glob)->dst[0]; dst[1]=(*glob)->dst[1]; dst[2]=(*glob)->dst[2];
switch(kle->seqh.channels) {
    case 3:
        IN32(sGlob->tab[UseF32-1],pixmap,src[0],src[1],src[2],width,height,rowByte
        break;
}

/*.....
 *
 * Klics encode
 *
 *.....*/
#ifdef DEBUG
if (p->callerFlags&codecFlagUseImageBuffer) DebugStr("\pUseImageBuffer"); /*
if (p->callerFlags&codecFlagUseScreenBuffer) DebugStr("\pUseScreenBuffer"); /*
if (p->callerFlags&codecFlagUpdatePrevious) DebugStr("\pUpdatePrevious"); /*
if (p->callerFlags&codecFlagNoScreenUpdate) DebugStr("\pNoScreenUpdate"); /*
if (p->callerFlags&codecFlagDontOffscreen) DebugStr("\pDontOffscreen"); /*
if (p->callerFlags&codecFlagUpdatePreviousComp) DebugStr("\pUpdatePreviousComp
if (p->callerFlags&codecFlagForceKeyFrame) DebugStr("\pForceKeyFrame"); /*
if (p->callerFlags&codecFlagOnlyScreenUpdate) DebugStr("\pOnlyScreenUpdate");
#endif

kle->buf.buf=(unsigned long *) (p->data+sizeof(KlicsFrameHeader));
kle->encl.intra=(p->temporalQuality==0);
kle->frmh.frame_number=p->frameNumber;

bytes=KlicsEncode(src,dst,kle);

BlockMove((Ptr)&kle->frmh,p->data,sizeof(KlicsFrameHeader));
bytes+=sizeof(KlicsFrameHeader);

(*glob)->prev_frame=p->frameNumber;

p->data+=bytes;
p->bufferSize=bytes;
(*p->imageDescription)->dataSize=bytes;

p->similarity=(kle->encl.intra?0:Long2Fix(244));
p->callerFlags=0;
/* p->callerFlags|=codecFlagUsedImageBuffer|(kle->encl.intra?codecFlagUsedNewImag
bail:

HUnlock((Handle)glob);
#ifdef PERFORMANCE
if(0!=(result=PerfDump(ThePGlobals,"pEncode.perf",false,0))
    return(result);
#endif
DebugMsg("\pBandCompress success");
return(result);
}
#endif

/* Display stuff for debugging
CGrafPtr wPort, savePort;

```

- 699 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

Rect      rect;
Str255    str;

GetPort((GrafPtr *)&savePort);
GetCWMgrPort(&wPort);
SetPort((GrafPtr)wPort);
SetRect(&rect, 0, 0, 50, 30);
ClipRect(&rect);
EraseRect(&rect);
NumToString(frmh->frame_number, str);
MoveTo(0, 20);
DrawString(str);
if (frmh->flags & KFH_INTRA) {
    SetRect(&rect, 0, 30, 50, 65);
    ClipRect(&rect);
    EraseRect(&rect);
    NumToString(frmh->frame_number/24, str);
    MoveTo(0, 50);
    DrawString(str);
}
SetRect(&rect, -2000, 0, 2000, 2000);
ClipRect(&rect);
SetPort((GrafPtr)savePort); */

#define flag_tree    0x1
#define flag_wave    0x2
#define flag_show    0x4
#define flag_full    0x8
#define DURATION     66666

long  ModeSwitch(Globals *glob, KlicsFrameHeader *frmh)
{
    long  mode=0, i, fps;
    Boolean repeat=glob->prev_frame==frmh->frame_number,
           next=glob->prev_frame+1==frmh->frame_number;
    CGrafPtr wPort, savePort;
    Rect      rect;
    Str255    str;

    DebugMsg("\pModeSwitch - begin");
    if (frmh->frame_number==0)
        for(i=0; i<15; i++) glob->out[i]=false;
    if (repeat) {
        glob->run_time=0;
        DebugMsg("\pModeSwitch - repeat (end)");
        return(flag_snow|flag_full);
    }

    if (next)
        switch(frmh->flags) {
            case KFH_SKIP:
                DebugMsg("\pModeSwitch - next/skip");
                glob->prev_frame=frmh->frame_number;
                if (glob->sys_time>DURATION) {
                    glob->run_time=0;
                    if (glob->real_frame!=glob->dpy_frame)
                        mode|=flag_wave|flag_show;
                } else {
                    unsigned long frame, late;

                    frame=glob->run_frame+(glob->sync_time-glob->run_time)/DURATION;
                    late=(glob->sync_time-glob->run_time)%DURATION;
                    if (frame<=glob->prev_frame && glob->real_frame!=glob->dpy_frame)

```

- 700 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

        mode!=flag_wave|flag_show;
/*      if (frame<=glob->prev_frame && late+glob->wave_time+glob->apy_time
        mode!=flag_wave|flag_show;*/
    }
    break;
case KFH_INTRA:
    DebugMsg("\pModeSwitch - next/intra");
    mode=flag_tree;
    glob->prev_frame=frmh->frame_number;
    glob->real_frame=glob->prev_frame;
    if (glob->sys_time>DURATION) {
        glob->run_time=0;
        mode!=flag_wave|flag_show|flag_full;
/*    } else
        if (glob->run_time==0) {*/
            glob->key_time=glob->sync_time-glob->run_time;
            glob->run_time=glob->sync_time-glob->sys_time;
            glob->run_frame=glob->prev_frame;
            mode!=flag_wave|flag_show|flag_full;
/*    } else {
            unsigned long frame, late;

            frame=glob->run_frame+(glob->sync_time-glob->run_time)/DURATION;
            late=(glob->sync_time-glob->run_time)%DURATION;
            if (frame<=glob->prev_frame)
                mode!=flag_wave|flag_show|flag_full;
        }*/
    break;
default:
    DebugMsg("\pModeSwitch - next/inter");
    mode=flag_tree;
    glob->prev_frame=frmh->frame_number;
    glob->real_frame=glob->prev_frame;
    if (glob->sys_time>DURATION) {
        glob->run_time=0;
        mode!=flag_wave|flag_show;
    } else
        if (glob->run_time==0) {
            glob->run_time=glob->sync_time-glob->sys_time;
            glob->run_frame=glob->prev_frame;
            mode!=flag_wave|flag_show;
        } else {
            unsigned long frame, late;

            frame=glob->run_frame+(glob->sync_time-glob->run_time)/DURATION;
            late=(glob->sync_time-glob->run_time)%DURATION;
            if (frame<=glob->prev_frame)
                mode!=flag_wave|flag_show;
/*            if (frame<=glob->prev_frame && late+glob->tree_time+glob->wave
                mode!=flag_wave|flag_show;*/
        }
    break;
}
else
    switch(frmh->flags) {
    case KFH_SKIP:
        DebugMsg("\pModeSwitch - jump/skip");
        glob->run_time=0;
        break;
    case KFH_INTRA:
        DebugMsg("\pModeSwitch - jump/intra");
        mode=flag_tree|flag_wave|flag_show|flag_full;
        for(i=glob->prev_frame;i<frmh->frame_number;i++)

```

- 701 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

        glob->out[frmh->frame_number%15]=0;
        glob->prev_frame=frmh->frame_number;
        glob->real_frame=glob->prev_frame;
        glob->run_time=0;
        break;
    default:
        DebugMsg("\pModeSwitch - jump/inter");
        glob->run_time=0;
        break;
    }
    DebugMsg("\pModeSwitch - display info");
#endif COMPONENT
/* glob->out[frmh->frame_number%15]=(mode&flag_show)!=0;
   for(i=0,fps=0;i<15;i++) if (glob->out[i]) fps++;
   GetPort((GrafPtr *)&savePort);
   GetCWMgrPort(&wPort);
   SetPort((GrafPtr)wPort);
   SetRect(&rect,0,20,120,50);
   ClipRect(&rect);
   EraseRect(&rect);
   NumToString(frmh->frame_number,str);
   MoveTo(0,35);
   DrawString(str);
   DrawString("\p:");
   NumToString(fps,str);
   DrawString(str);
   MoveTo(0,50);
   for(i=0;i<15;i++)
       if (glob->out[i]) DrawString("\pX");
       else DrawString("\pO");
   SetRect(&rect,-2000,0,2000,2000);
   ClipRect(&rect);
   SetPort((GrafPtr)savePort);*/
#endif
    DebugMsg("\pModeSwitch - end");
    return(mode);
}

#ifndef ENCODER
pascal long
KLBandDecompress(Handle storage,register CodecDecompressParams *p)
{
    pragma unused(storage)
    Globals **glob = (Globals **)storage;
    ImageDescription **desc = p->imageDescription;
    int x,y;
    char *baseAddr;
    short rowBytes;
    Rect dRect;
    long offsetH,offsetV;
    OSErr result = noErr;
    short *src[3],*dst[3];
    long *pixmap;
    int width=(*desc)->width+KLExtendWidth((*desc)->width);
    int height=(*desc)->height+KLExtendHeight((*desc)->height);
    int hwidth=width>>1,hheight=height>>1,area=height*width;
    KlicsE kle;
    KlicsFrameHeader *frmh;
    char mmuMode=1;
    long mode;
    SharedGlobals *sGlob;
/*
    FILE *fp;

```



- 702 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

char          file_name[30];
CGrafPtr      wPort, savePort;
Rect          rect;
Str255        str;
*/

HLock((Handle)glob);
DebugMsg("\pBandDecompress");
(*glob)->sys_time=GetTimerValue(&(*glob)->sys_time);
(*glob)->sys_time-=(*glob)->sync_time;

#ifdef PERFORMANCE
(void)PerfControl(ThePGlobals,true);
#endif

kle=(*glob)->kle;
sGlob=(*glob)->sharedGlob;

dRect = p->srcRect;
if ( !TransformRect(p->matrix,&dRect,nil) ) {
    DebugMsg("\pTransformRect Error");
    return(paramErr);
}
rowBytes = p->dstPixMap.rowBytes & 0x1fff;
offsetH = (dRect.left - p->dstPixMap.bounds.left);
switch ( p->dstPixMap.pixelSize ) {
case 32:
    offsetH <=&2;
    break;
case 16:
    offsetH <=&1;
    break;
case 8:
    break;
default:
    result = codecErr;
    DebugMsg("\pDepth Error");
    goto bail;
}
offsetV = (dRect.top - p->dstPixMap.bounds.top) * rowBytes;
baseAddr = p->dstPixMap.baseAddr + offsetH + offsetV;
pixmap=(long *)baseAddr;

/*****
 *
 *   Klics decode
 *
 *****/

src[0]=(*glob)->src[0]; src[1]=(*glob)->src[1]; src[2]=(*glob)->src[2];
dst[0]=(*glob)->dst[0]; dst[1]=(*glob)->dst[1]; dst[2]=(*glob)->dst[2];

frmh=(KlicsFrameHeader *)p->data;
kle->buf.buf=(unsigned long *) (p->data+sizeof(KlicsFrameHeader));
mode=ModeSwitch(*glob,frmh);

KlicsDecode(src,dst,&kle->seqh,frmh,&kle->buf,mode,(*glob)->scale,&(*glob)->tr

if ( kle->buf.ptr-kle->buf.buf > frmh->length+2)
    DebugMsg("\pWarning: Decompressor read passed end of buffer");

p->data[0]='X';
p->data[1]=mode&flag_tree?'T':' ';

```

- 703 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

p->data[2]=mode&flag_wave?'W':' ';
p->data[3]=mode&flag_show?'S':' ';
p->data[4]=mode&flag_full?'F':' ';
p->data[5]=frmh->flags&KFH_INTRA?'I':' ';
p->data[6]=frmh->flags&KFH_SKIP?'K':' ';
p->data[7]='X';

p->data+=p->bufferSize;

/*****
 *
 * signed 10 bit YUV-unsigned 8 RGB convert
 *****/

#ifdef COMPONENT
SwapMMUMode(&mmuMode);
#endif
if (mode&flag_show) {
    (*glob)->sync_time=GetTimerValue(&(*glob)->sync_time);
    (*glob)->dpy_frame=(*glob)->real_frame;
    if ((*glob)->scale[2]<(*glob)->scale[1]) {
        switch(kle->seqh.channels) {
            case 3:
                switch (p->dstPixmap.pixelSize) {
                    case 32:
                        if (mode&flag_full)
                            OUT32X2(sGlob->tab[Use32-1],pixmap,src[0],src[1],src[2],wi
                        else
                            OUT32X2D(sGlob->tab[Use32-1],pixmap,src[0],src[1],src[2],w
                        break;
                    case 16:
                        OUT16X2(sGlob->tab[Use16-1],pixmap,src[0],src[1],src[2],width>
                        break;
                    case 8:
                        OUT8X2(sGlob->tab[Use8-1],pixmap,src[0],src[1],src[2],width>>
                        break;
                }
                break;
            }
        } else {
            switch(kle->seqh.channels) {
                case 3:
                    switch (p->dstPixmap.pixelSize) {
                        case 32:
                            if (mode&flag_full)
                                OUT32(sGlob->tab[Use32-1],pixmap,src[0],src[1],src[2],width>
                            else
                                OUT32D(sGlob->tab[Use32-1],pixmap,src[0],src[1],src[2],wid
                            break;
                        case 16:
                            OUT16(sGlob->tab[Use16-1],pixmap,src[0],src[1],src[2],width>>
                            break;
                        case 8:
                            OUT8(sGlob->tab[Use8-1],pixmap,src[0],src[1],src[2],width>>(*g
                            break;
                    }
                }
            }
        }
    }
    (*glob)->dpy_time=GetTimerValue(&(*glob)->dpy_time);
    (*glob)->dpy_time-=(*glob)->sync_time;
}

```

- 704 -

Engineering:KlicsCode:CompPict:KlicsCodec.c

```
CLEARA2();
(*glob)->sync_time=GetTimerValue(&(*glob)->sync_time);

#ifdef COMPONENT
    SwapMMUMode(&mmuMode);
#endif

bail:
    HUnlock((Handle)glob);

#ifdef PERFORMANCE
    if(0!=(result=PerfDump(ThePGlobals,"pDecode.perf",false,0)))
        return(result);
#endif
    DebugMsg("\pBandDecompress success");
    return(result);
}
#endif
```

Engineering:KlicsCode:CompPict:Klics.h

```

/*****
 *
 *  © Copyright 1993 KLICS Limited
 *  All rights reserved.
 *
 *  Written by: Adrian Lewis
 *****/
/*
 *  Second generation header file
 */

#include    <stdio.h>

/* useful X definitions */
/*typedef char    Boolean;*/
typedef char    *String;
#define True    1
#define False    0

/* new Blk definition */
typedef int    Blk[4];

#define WT_Haar    0
#define WT_Daub4    1

/* mode constructors */
#define M_LPF    1
#define M_STILL    2
#define M_SEND    4
#define M_STOP    8
#define M_VOID    16
#define M_QUIT    32

/* LookAhead histogram */
#define HISTO    300
#define HISTO_DELTA    15.0
#define HISTO_BITS    10

/* Fast Functions */

/* Is the block all zero ? */
#define BlkZero(block) \
    block[0]==0 && block[1]==0 && block[2]==0 && block[3]==0

/* Sum of the absolute values */
#define Decide(new) \
    abs(new[0])+ \
    abs(new[1])+ \
    abs(new[2])+ \
    abs(new[3])

/* Sum of the absolute differences */
#define DecideDelta(new,old) \
    abs(new[0]-old[0])+ \
    abs(new[1]-old[1])+ \
    abs(new[2]-old[2])+ \
    abs(new[3]-old[3])

/* Adjust the norm for comparison with SigmaAbs */
#define DecideDouble(norm)    (4.0*norm)

/* Get addresses from x,y coords of block, sub-band, octave,

```

- 706 -

Engineering:KlicsCode:CompPict:Klics.h

```

/* image size and mask (directly related to octave) information */
#define GetAddr(addr,x,y,sub,oct,size,mask) \
{ int    smask=mask>>1, \
  x0=x!(sub&1?smask:0), \
  x1=x!(sub&1?smask:0)|mask, \
  y0=(y!(sub&2?smask:0))*size[0], \
  y1=(y!(sub&2?smask:0)|mask)*size[0]; \
  \
  addr[0]=x0+y0; \
  addr[1]=x1+y0; \
  addr[2]=x0+y1; \
  addr[3]=x1+y1; \
}

/* Get data values from addresses and memory */
#define GetData(addr,block,data) \
block[0]=(int)data[addr[0]]; \
block[1]=(int)data[addr[1]]; \
block[2]=(int)data[addr[2]]; \
block[3]=(int)data[addr[3]];

#define VerifyData(block,mask,tmp) \
tmp=block&mask; \
if (tmp!=0 && tmp!=mask) { \
  block=block<0?mask:-mask; \
}

/* Put data values to memory using addresses */
#define PutData(addr,block,data) \
data[addr[0]]=(short)block[0]; \
data[addr[1]]=(short)block[1]; \
data[addr[2]]=(short)block[2]; \
data[addr[3]]=(short)block[3];

/* Put zero's to memory using addresses */
#define PutZero(addr,data) \
data[addr[0]]=0; \
data[addr[1]]=0; \
data[addr[2]]=0; \
data[addr[3]]=0;

/* Mode: M_VOID Put zero's and find new mode */
#define DoZero(addr,dst,mode,oct) \
PutZero(addr,dst); \
mode[oct]=oct==0?M_STOP:M_VOID;

/* Descend the tree structure
 * Copy mode, decrement octave (& mask), set branch to zero
 */
#define DownCounters(mode,oct,mask,blk) \
mode[oct-1]=mode[oct]; \
oct--; \
mask = mask>>1; \
blk[oct]=0;

/* Ascend the tree structure
 * Ascend tree (if possible) until branch not 3
 * If at top then set mode to M_QUIT
 * Else increment branch and x, y coords
 */
#define StopCounters(mode,oct,mask,blk,x,y,octs) \
while(oct<octs-1 && blk[oct]==3) { \

```

- 707 -

Engineering:KlicsCode:CompPict:Klics.h

```
    blk{oct}=0; \
    mask= mask<<1; \
    x &= ~mask; \
    y &= ~mask; \
    oct++; \
} \
if (oct==octx-1) mode{oct}=M_QUIT; \
else { \
    blk{oct}++; \
    x ^= mask<<1; \
    if (blk{oct}==2) y ^= mask<<1; \
    mode{oct}=mode{oct+1}; \
}
```

Engineering:KlicsCode:CompPict:Haar.a

```

-----
*
*   © Copyright 1993 KLICS Limited
*   All rights reserved.
*
*   Written by: Adrian Lewis
*
-----
*
*   68000 FastForward/Backward Haar
*
-----
*
*   macro
*   Fwd0          &addr0,&dG,&dH
*
*   move.w        (&addr0),&dG      ; dG=*(short *)addr1
*   move.w        &dG,&dH           ; dH=dG
*
*   endm
*
-----
*
*   macro
*   Fwd1          &addr1,&addr0,&dG,&dH
*
*   move.w        (&addr1),d0        ; v=*(short *)addr2
*   add.w         d0,&dH              ; dH+=v
*   sub.w         d0,&dG              ; dG-=v
*   clr.w         d0                 ; d0=0
*   asr.w         #1,&dH              ; dAH>>=1
*   addx.w        d0,&dH              ; round dH
*   asr.w         #1,&dG              ; dG>>=1
*   addx.w        d0,&dG              ; round dG
*   move.w        &dH,(&addr0)        ; *(short *)addr0=dH
*   move.w        &dG,(&addr1)        ; *(short *)addr1=dG
*
*   mnd
*
-----
*
*   macro
*   Fwd          &base,&end,&inc
*
*   movea.l       &base,a0           ; addr0=base
*   move.l        &inc,d0            ; d0=inc
*   asr.l         #1,d0              ; d0=inc>>1
*   movea.l       a0,a1              ; addr1=addr0
*   suba.l        d0,a1              ; addr1-=(inc>>1)
*   @do Fwd0      a0,d4,d5            ; Fwd0(addr0,dG,dH)
*   adda.l        &inc,a1            ; addr1+=inc
*   Fwd1          a1,a0,d4,d5        ; Fwd1(addr1,addr0,dG,dH)
*   adda.l        &inc,a0            ; addr0+=inc
*   cmpa.l        a0,&end            ; addr0<end
*   bgt.s         @do               ; while
*
*   endm
*
-----
*
HaarForward FUNC      EXPORT
*
*   link          a6,#0              ; no local variables
*   movem.l       d4-d7/a3-a5,-(a7)  ; store registers
*
*   move.l        $000C(a6),d3        ; inc=incl
*   movea.l       $0008(a6),a5        ; base=data
*   move.l        $0010(a6),d6        ; end1
*   move.l        $0018(a6),d7        ; end2
*   move.l        $0014(a6),d2        ; inc2

```

- 709 -

Engineering:KlicsCode:CompPict:Haar.a

```

@do    movea.l    a5,a4                ; end=base
      adda.l    d6,a4                ; end+=endl
      Fwd      a5,a4,d3              ; Fwd(base,end,inc)
      adda.l    d2,a5                ; base+=inc2
      cmpa.l    d7,a5                ; end2>base
      blt.s     @do                  ; for

      movem.l    (a7)+,d4-d7/a3-a5    ; restore registers
      unlk      a6                  ; remove locals
      rts                          ; return

      ENDFUNC
-----
      macro
      Bwd0      &addr0,&dG,&dH

      move.w     (&addr0),&dG        ; dG=*(short *)&addr0
      move.w     &dG,&dH              ; dH=dG

      endm
-----
      macro
      Bwd1      &addr1,&addr0,&dG,&dH

      move.w     (&addr1),d0         ; v=*(short *)&addr1
      add.w      d0,&dH               ; dH+=v
      sub.w      d0,&dG               ; dG-=v
      move.w     &dH,(&addr0)        ; *(short *)&addr0=dH
      move.w     &dG,(&addr1)        ; *(short *)&addr1=dG

      endm
-----
      macro
      Bwd       &base,&count,&inc

      movea.l    &base,a0            ; addr0=base
      move.l     &inc,d0              ; d0=inc
      asr.l      #1,d0               ; d0=inc>>1
      movea.l    a0,a1               ; addr1=addr0
      suba.l     d0,a1               ; addr1-=(inc>>1)
@do    Bwd0      a0,d4,d5              ; Bwd0(addr0,dG,dH)
      adda.l     &inc,a1              ; addr1+=inc
      Bwd1      a1,a0,d4,d5          ; Bwd1(addr1,addr0,dG,dH)
      adda.l     &inc,a0              ; addr0+=inc
      dbf        &count,@do          ; while --count

      endm
-----
HaarBackward    FUNC    EXPORT
*
*    d0 - spare, d1 - count1, d2 - inc2, d3 - inc1, d4 - dG, d5 - dH, d6 - loop1, d
*
      link       a6,#0                ; no local variables
      movem.l    d4-d7/a3-a5,-(a7)    ; store registers

      move.l     $000C(a6),d3         ; inc=inc1
      movea.l    $0008(a6),a5         ; base=data
      move.l     $0010(a6),d6         ; loop1 (width/height)
      move.l     $0018(a6),d7         ; loop2 (height/width)
      move.l     $0014(a6),d2         ; inc2
      subq.l     #1,d7                ; loop2-=1
      lsr.l      #1,d6                ; loop1/=2
      subq.l     #1,d6                ; loop1-=1

```



- 710 -

Engineering:KiicsCode:CompPict:Haar.a

```

@do      move.l    d6,d1          ; count1=loop1
        Bwd       a5,d1,d3       ; Bwd(base.count,inc)
        adda.l    d2,a5          ; base+=inc2
        dbf       d7,@do        ; while -1!--loop2
*
        movem.l   (a7)+,d4-d7/a3-a5 ; restore registers
        unlk      a6             ; remove locals
        rts                ; return

```

ENDFUNC

HaarXTopBwd FUNC EXPORT

```

*      link        a6,#0          ; no local variables
*
        movea.l    $0008(a6),a0    ; start
        movea.l    $000C(a6),d3    ; area
        lsr.l      #1,d3           ; area (long)
        subq.l     #1,d3           ; area--=1
@do     move.l     (a0),d0          ; d0=HG=*Y
        move.l     d0,d1           ; d1=HG
        swap       d1              ; d1=GH
        neg.w      d0              ; d0=H(-G)
        add.l      d1,d0           ; d0=01
        move.l     d0,(a0)+        ; *Y++=01
        dbf       d3,@do          ; while -1!--area
*
        unlk      a6              ; remove locals
        rts                ; return

```

ENDFUNC

HaarTopBwd FUNC EXPORT

```

*      link        a6,#0          ; no local variables
*      movem.l     d4-d6,-(a7)    ; store registers
*
        movea.l    $0008(a6),a0    ; startH
        movea.l    a0,a1           ; startG
        move.l     $000C(a6),d4    ; height
        move.l     $0010(a6),d3    ; width
        move.l     d3,d6           ; linelen=width
        add.l      d6,d6           ; linelen (bytes)
        lsr.l      #1,d4           ; height/=2
        lsr.l      #1,d3           ; width/=2
        subq.l     #1,d4           ; height-=1
        subq.l     #1,d3           ; width-=1
@dol    adda.l     d6,a1            ; startG+=linelen
        move.l     d3,d5           ; linecount=width
@do2    move.l     (a0),d0          ; d0=HAHB=*Y0
        move.l     (a1),d1          ; d1=GAGB=*Y1
        move.l     d0,d2           ; d2=HAHB
        add.l      d1,d0           ; d0=0A0B
        sub.l      d1,d2           ; d2=1A1B
*
        move.l     d0,d1           ; d1=HG
        swap       d1              ; d1=GH
        neg.w      d0              ; d0=H(-G)
        add.l      d1,d0           ; d0=01
        move.l     d0,(a0)+        ; *Y0++=0A0B
*
        move.l     d2,d1           ; d1=HG
        swap       d1              ; d1=GH

```

- 711 -

Engineering:KlicsCode:CompPict:Haar.a

```
neg.w      d2
add.l      d1,d2          ; d2=H(-G)
move.l     d2,(a1)+       ; d2=01
*          ; *Y1++=1A1B

dbf        d5,@do2
move.l     a1,a0          ; while -1!--linecount
dbf        d4,@do1       ; startH=startG
*          ; while -1!--height

movem.l    (a7)+,d4-d6    ; restore registers
unlk       a6            ; remove locals
rts
*          ; return

ENDFUNC
*-----
END
```

- 712 -

Engineering:KlicsCode:CompPict:ConvolveSH3.c

```

/*.....
 *
 *  © Copyright 1993 KLICS Limited
 *  All rights reserved.
 *
 *  Written by: Adrian Lewis
 *
 *.....*/
/*
 2D wavelet transform convolver (fast hardware emulation)
 New improved wavelet coeffs : 11 19 5 3

 Optimized for speed:
   dirn - False
   src/dst octave == 0
*/

#define FwdS(addr0,dAG,dAH) \
  v=(short *)addr0; \
  dAG=(v3=v+(vs=v<<1)); \
  dAG+=v+(vs<=1); \
  dAH=v3+(vs<=1); \
  dAH+=v3+(vs<=1);

#define Fwd1(addr1,dAG,dAH,dBG,dBH) \
  v=(short *)addr1; \
  dBG=(v3=v+(vs=v<<1)); \
  dAH+=v+(vs<=1); \
  dBH=v3+(vs<=1); \
  dAG-=v3+(vs<=1);

#define Fwd2(addr2,addr1,addr0,dAG,dAH,dBG,dBH) \
  v=(short *)addr2; \
  dAH-=v3=v+(vs=v<<1); \
  dBG+=v+(vs<=1); \
  dAG+=v3+(vs<=1); \
  dBH+=v3+(vs<=1); \
  *(short *)addr0=(dAH+15)>>5; \
  *(short *)addr1=(dAG+15)>>5;

#define Fwd3(addr3,dAG,dAH,dBG,dBH) \
  v=(short *)addr3; \
  dAG=(v3=v+(vs=v<<1)); \
  dBH+=v+(vs<=1); \
  dAH=v3+(vs<=1); \
  dBG-=v3+(vs<=1);

#define Fwd0(addr0,addr3,addr2,dAG,dAH,dBG,dBH) \
  v=(short *)addr0; \
  dBH-=v3=v+(vs=v<<1); \
  dAG+=v+(vs<=1); \
  dBG+=v3+(vs<=1); \
  dAH+=v3+(vs<=1); \
  *(short *)addr2=(dBH+15)>>5; \
  *(short *)addr3=(dBG+15)>>5;

#define FwdE(addr3,addr2,dBG,dBH) \
  v=(short *)addr3; \
  dBH+=(vs=v<<1); \
  dBG+=(vs<<2); \
  *(short *)addr2=(dBH+15)>>5; \
  *(short *)addr3=(dBG+15)>>5;

```

Engineering:KlicsCode:CompPict:ConvolveSH3.c

```

#define Fwd(base, end, inc) \
    addr0=base; \
    addr3=addr0-(inc>>2); \
    addr2=addr3-(inc>>2); \
    addr1=addr2-(inc>>2); \
    FwdS(addr0,dAG,dAH); \
    addr1+=inc; \
    Fwd1(addr1,dAG,dAH,dBG,dBH); \
    addr2+=inc; \
    Fwd2(addr2,addr1,addr0,dAG,dAH,dBG,dBH); \
    addr3+=inc; \
    while(addr3<end) { \
        Fwd3(addr3,dAG,dAH,dBG,dBH); \
        addr0+=inc; \
        Fwd0(addr0,addr3,addr2,dAG,dAH,dBG,dBH); \
        addr1+=inc; \
        Fwd1(addr1,dAG,dAH,dBG,dBH); \
        addr2+=inc; \
        Fwd2(addr2,addr1,addr0,dAG,dAH,dBG,dBH); \
        addr3+=inc; \
    } \
    FwdE(addr3,addr2,dBG,dBH);

extern void FASTFORWARD(char *data, long incl, long end1, long inc2, char *end2);
extern void HAARFORWARD(char *data, long incl, long end1, long inc2, char *end2);

void FastForward(char *data, long incl, long end1, long inc2, char *end2)
{
    register short v, vs, v3, dAG, dAH, dBG, dBH, inc;
    register char *addr0, *addr1, *addr2, *addr3, *end;
    char *base;

    inc=incl;
    for(base=data;base<end2;base+=inc2) {
        end=base+end1;
        Fwd(base, end, inc);
    }
}

void Daub4Forward(short *data, int size[2], int oct_dst)
{
    int oct, area=size[0]*size[1]<<1;
    short width=size[0]<<1;
    char *top=area+(char *)data, *left=width+(char *)data;

    for(oct=0;oct!=oct_dst;oct++) {
        long cinc=2<<oct, cinc4=cinc<<2,
            rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in t
        FASTFORWARD((char *)data,cinc4,width-cinc,rinc,top);
        FASTFORWARD((char *)data,rinc4,area-rinc,cinc,left);
    }
}

void HaarForward(short *data, int size[2], int oct_dst)
{
    int oct, area=size[0]*size[1]<<1;
    short width=size[0]<<1;
    char *top=area+(char *)data, *left=width+(char *)data;

    for(oct=0;oct!=oct_dst;oct++) {
        long cinc=2<<oct, cinc2=cinc<<1,

```

- 714 -

Engineering:KlicsCode:CompPict:ConvoiveSH3.c

```

    rinc=size[0]<<oct+1, rinc2=rinc<<1; /* col and row increments in t
    HAARFORWARD((char *)data,cinc2,width,rinc,top);
    HAARFORWARD((char *)data,rinc2,area,cinc,left);
}

void HybridForward(short *data, int size[2], int oct_dst)
{
    int    oct, area=size[0]*size[1]<<1;
    short  width=size[0]<<1;
    char   *top=area+(char *)data, *left=width+(char *)data;

    HAARFORWARD((char *)data,4,width,size[0]<<1,top);
    HAARFORWARD((char *)data,size[0]<<2,area,2,left);
    for(oct=1;oct!=oct_dst;oct++) {
        long  cinc=2<<oct, cinc4=cinc<<2,
              rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in t
        FASTFORWARD((char *)data,cinc4,width-cinc,rinc,top);
        FASTFORWARD((char *)data,rinc4,area-rinc,cinc,left);
    }
}

#define BwdS0(addr0,dAG,dAH,dBH) \
    v=(short *)addr0; \
    dAG= -(v3=v+(vs=v<<1)); \
    dAH=v+(vs<<=1); \
    dBH=vs<<1; \

#define BwdS1(addr1,addr0,dAG,dAH,dBH) \
    v=(short *)addr1; \
    dBH+=(vs=v<<1); \
    v3=vs+v; \
    dAG+=v3+(vs<<=2); \
    dAH-=v3+(vs<<=1); \
    *(short *)addr0=(dBH+3)>>3;

#define Bwd2(addr2,dAG,dAH,dBG,dBH) \
    v=(short *)addr2; \
    dBG= -(v3=v+(vs=v<<1)); \
    dBH=v+(vs<<=1); \
    dAH+=v3+(vs<<=1); \
    dAG+=v3+(vs<<=1); \

#define Bwd3(addr3,addr2,addr1,dAG,dAH,dBG,dBH) \
    v=(short *)addr3; \
    dAH+=(v3=v+(vs=v<<1)); \
    dAG+=v+(vs<<=1); \
    dBG+=v3+(vs<<=1); \
    dBH-=v3+(vs<<=1); \
    *(short *)addr1=(dAH+7)>>4; \
    *(short *)addr2=(dAG+7)>>4;

#define Bwd0(addr0,dAG,dAH,dBG,dBH) \
    v=(short *)addr0; \
    dAG= -(v3=v+(vs=v<<1)); \
    dAH=v+(vs<<=1); \
    dBH+=v3+(vs<<=1); \
    dBG+=v3+(vs<<=1); \

#define Bwd1(addr1,addr0,addr3,dAG,dAH,dBG,dBH) \
    v=(short *)addr1; \

```

- 715 -

Engineering:KlicsCode:CompPict:ConvolveSH3.c

```

    dBH+=(v3=v+(vs=v<<1)); \
    DBG+=v+(vs<=1); \
    DAG+=v3+(vs<=1); \
    dAH-=v3+(vs<=1); \
    *(short *)addr3=(dBH+7)>>4; \
    *(short *)addr0=(DBG+7)>>4;

#define BwdE2(addr2,dAG,dAH,dBH) \
    v=(short *)addr2; \
    v3=v+(vs=v<<1); \
    dBH=(vs<=2); \
    dAH+=v3+vs; \
    dAG+=v3+(vs<=1);

#define BwdE3(addr3,addr2,addr1,dAG,dAH,dBH) \
    v=(short *)addr3; \
    dAH+=(v3=v+(vs=v<<1)); \
    dAG+=v+(vs<=1); \
    dBH-=v3+(vs<=1); \
    dBH+=v3+(vs<=1); \
    *(short *)addr1=(dAH+7)>>4; \
    *(short *)addr2=(dAG+7)>>4; \
    *(short *)addr3=(dBH+3)>>3;

#define Bwd(base,end,inc) \
    addr0=base; \
    addr3=addr0-(inc>>2); \
    addr2=addr3-(inc>>2); \
    addr1=addr2-(inc>>2); \
    BwdS0(addr0,dAG,dAH,dBH); \
    addr1+=inc; \
    BwdS1(addr1,addr0,dAG,dAH,dBH); \
    addr2+=inc; \
    while(addr2<end) { \
        Bwd2(addr2,dAG,dAH,dBG,dBH); \
        addr3+=inc; \
        Bwd3(addr3,addr2,addr1,dAG,dAH,dBG,dBH); \
        addr0+=inc; \
        Bwd0(addr0,dAG,dAH,dBG,dBH); \
        addr1+=inc; \
        Bwd1(addr1,addr0,addr3,dAG,dAH,dBG,dBH); \
        addr2+=inc; \
    } \
    BwdE2(addr2,dAG,dAH,dBH); \
    addr3+=inc; \
    BwdE3(addr3,addr2,addr1,dAG,dAH,dBH);

extern void FASTBACKWARD(char *data, long incl, long loop1, long inc2, char *end2)
extern void HAARBACKWARD(char *data, long incl, long loop1, long inc2, long loop2)
extern void HAARTOPBWD(char *data, long height, long width);
/* extern void HAARXTOPBWD(char *data, long area); */

void FastBackward(char *data, long incl, long endl, long inc2, char *end2)
{
    register short v, vs, v3, dAG, dAH, DBG, dBH, inc;
    register char *addr0, *addr1, *addr2, *addr3, *end;
    char *base;

    inc=incl;
    for(base=data; base<endl; base+=inc2) {
        end=base+endl;
        Bwd(base, end, inc);
    }
}

```

- 716 -

Engineering:KlicsCode:CompPict:ConvolveSH3.c

```

}

void Daub4Backward(short *data,int size[2],int oct_src)
{
    int    oct, area=size[0]*size[1]<<1;
    short  width=size[0]<<1;
    char   *top=area+(char *)data, *left=width+(char *)data;

    for(oct=oct_src-1;oct>=0;oct--) {
        long   cinc=2<<oct, cinc4=cinc<<2,
               rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in t

        FASTBACKWARD((char *)data,rinc4,area-(rinc<<1),cinc,left);
        FASTBACKWARD((char *)data,cinc4,width-(cinc<<1),rinc,top);
    }
}

void HaarBackward(data,size,oct_src)
short *data;
int size[2], oct_src;
{
    int    oct, area=size[0]*size[1]<<1;
    short  width=size[0]<<1;
    char   *top=area+(char *)data, *left=width+(char *)data;

    for(oct=oct_src-1;oct>0;oct--) {
        long   cinc=2<<oct, cinc2=cinc<<1,
               rinc=size[0]<<oct+1, rinc2=rinc<<1; /* col and row increments in t

        HAARBACKWARD((char *)data,rinc2,size[1]>>oct,cinc,size[0]>>oct);
        HAARBACKWARD((char *)data,cinc2,size[0]>>oct,rinc,size[1]>>oct);
    }
    HAARTOPBWD((char *)data,size[1],size[0]);
    /* HAARXTOPBWD((char *)data,area>>1);*/
}

void HybridBackward(data,size,oct_src)
short *data;
int size[2], oct_src;
{
    int    oct, area=size[0]*size[1]<<1;
    short  width=size[0]<<1;
    char   *top=area+(char *)data, *left=width+(char *)data;

    for(oct=oct_src-1;oct>0;oct--) {
        long   cinc=2<<oct, cinc4=cinc<<2,
               rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in t

        FASTBACKWARD((char *)data,rinc4,area-(rinc<<1),cinc,left);
        FASTBACKWARD((char *)data,cinc4,width-(cinc<<1),rinc,top);
    }
    HAARTOPBWD((char *)data,size[1],size[0]);
    /* HAARXTOPBWD((char *)data,area>>1);*/
}

```

Engineering:KlicsCode:CompPict:ConvolveSH3.a

```

*-----
*
*  © Copyright 1993 KLICS Limited
*  All rights reserved.
*
*  Written by: Adrian Lewis
*-----
*
*  68000 FastForward/Backward code
*-----
*
*      seg          'klics'
*
*      macro
*      FwdStart      &addr0,&dAG,&dAH
*
*      move.w        (&addr0),d0      ; v=*(short *)addr0
*      move.w        d0,d1            ; vs=v
*      add.w         d1,d1            ; vs<=1
*      move.w        d1,d2            ; v3=vs
*      add.w         d0,d2            ; v3=vs+v
*      move.w        d2,&dAG          ; dAG=v3
*      add.w         d1,d1            ; vs<=1
*      add.w         d0,&dAG          ; dAG+=v
*      add.w         d1,&dAG          ; dAG+=vs
*      move.w        d2,&dAH          ; dAH=v3
*      add.w         d1,d1            ; vs<=1
*      add.w         d1,&dAH          ; dAH+=vs
*      add.w         d2,&dAH          ; dAH+=v3
*      add.w         d1,d1            ; vs<=1
*      add.w         d1,&dAH          ; dAH+=vs
*
*      endm
*-----
*
*      macro
*      FwdOdd        &addr1,&dAG,&dAH,&DBG,&DBH
*
*      move.w        (&addr1),d0      ; v=*(short *)addr1
*      move.w        d0,d1            ; vs=v
*      add.w         d1,d1            ; vs<=1
*      move.w        d1,d2            ; v3=vs
*      add.w         d0,d2            ; v3=vs+v
*      move.w        d2,&DBG          ; DBG=v3
*      add.w         d1,d1            ; vs<=1
*      add.w         d0,&dAH          ; dAH+=v
*      add.w         d1,&dAH          ; dAH+=vs
*      move.w        d2,&DBH          ; DBH=v3
*      add.w         d1,d1            ; vs<=1
*      add.w         d1,&DBH          ; DBH+=vs
*      sub.w         d2,&dAG          ; dAG-=v3
*      add.w         d1,d1            ; vs<=1
*      sub.w         d1,&dAG          ; dAG-=vs
*
*      endm
*-----
*
*      macro
*      FwdEven       &addr2,&addr1,&addr0,&dAG,&dAH,&DBG,&DBH
*
*      move.w        (&addr2),d0      ; v=*(short *)addr2
*      move.w        d0,d1            ; vs=v
*      add.w         d1,d1            ; vs<=1
*      move.w        d1,d2            ; v3=vs

```



- 718 -

Engineering:KlicsCode:CompPict:ConvoiveSH3.a

```

add.w    d0,d2          ; v3=vs+v
sub.w    d2,&dAH         ; dAH-=v3
add.w    d1,d1          ; vs<=1
add.w    d0,&DBG         ; DBG+=v
add.w    d1,&DBG         ; DBG+=vs
add.w    d2,&dAG         ; dAG+=v3
add.w    d1,d1          ; vs<=1
add.w    d1,&dAG         ; dAG+=vs
add.w    d2,&dBH         ; dBH+=v3
add.w    d1,d1          ; vs<=1
add.w    d1,&dBH         ; dBH+=vs
clr.w    d0              ; d0=0
asr.w    #5,&dAH         ; dAH>>=5
addx.w   d0,&dAH         ; round dAH
asr.w    #5,&dAG         ; dAG>>=5
addx.w   d0,&dAG         ; round dAG
move.w   &dAH,(&addr0)   ; *(short *)addr0=dAH
move.w   &dAG,(&addr1)   ; *(short *)addr1=dAG

```

mend

```

macro
FwdEnd    &addr3,&addr2,&DBG,&dBH

```

```

move.w   (&addr3),d0    ; v=*(short *)addr3
add.w    d0,d0          ; v<=1
add.w    d0,&dBH         ; dBH+=v
lsl.w    #2,d0          ; v<=2
sub.w    d0,&DBG         ; DBG-=v
clr.w    d0              ; d0=0
asr.w    #5,&dBH         ; dBH>>=5
addx.w   d0,&dBH         ; round dBH
asr.w    #5,&DBG         ; DBG>>=5
addx.w   d0,&DBG         ; round DBG
move.w   &dBH,(&addr2)   ; *(short *)addr2=DBG
move.w   &DBG,(&addr3)   ; *(short *)addr3=DBG

```

endm

```

macro
Fwd        &base,&end,&inc

```

```

movea.l   &base,a0      ; addr0=base
move.l    &inc,d0        ; d0=inc
asr.l     #2,d0          ; d0=inc>>2
movea.l   a0,a3          ; addr3=addr0
suba.l    d0,a3          ; addr3-=inc>>2
movea.l   a3,a2          ; addr2=addr3
suba.l    d0,a2          ; addr2-=inc>>2
movea.l   a2,a1          ; addr1=addr2
suba.l    d0,a1          ; addr1-=inc>>2
FwdStart  a0,d4,d5       ; FwdStart(addr0,dAG,dAH)
adda.l    &inc,a1        ; addr1+=inc
FwdOdd    a1,d4,d5,d6,d7 ; FwdOdd(addr1,dAG,dAH,dBG,dBH)
adda.l    &inc,a2        ; addr2+=inc
FwdEven   a2,a1,a0,d4,d5,d6,d7 ; FwdEven(addr2,addr1,addr0,dAG,dAH,dB)
adda.l    &inc,a3        ; addr3+=inc
@do FwdOdd  a3,d6,d7,d4,d5 ; FwdOdd(addr3,dBG,dBH,dAG,dAH)
adda.l    &inc,a0        ; addr0+=inc
FwdEven   a0,a3,a2,d6,d7,d4,d5 ; FwdEven(addr0,addr3,addr2,dBG,dBH,dA)
adda.l    &inc,a1        ; addr1+=inc
FwdOdd    a1,d4,d5,d6,d7 ; FwdOdd(addr1,dAG,dAH,dBG,dBH)
adda.l    &inc,a2        ; addr2+=inc

```

- 719 -

Engineering:KlicsCode:CompPict:ConvolveSH3.a

```

FwdEven      a2,a1,a0,d4,d5,d6,d7      ; FwdEven(addr2,addr1,addr0,dAG,dAH,dB
adda.l       &inc,a3                    ; addr3+=inc
cmpa.l       a3,&end                    ; addr3<end
bgt.w        @do                        ; while
FwdEnd       a3,a2,d6,d7                ; FwdEnd(addr3,addr2,dBG,dBH)

*
*      endm
*-----
FastForward FUNC      EXPORT
*
*      link      a6,#0                    ; no local variables
*      movem.l   d4-d7/a3-a5,-(a7)        ; store registers
*
*      move.l    $000C(a6),d3              ; inc=inc1
*      movea.l   $0008(a6),a5              ; base=data
*      @do      movea.l   a5,a4              ; end=base
*      adda.l    $0010(a6),a4              ; end+=end1
*      Fwd      a5,a4,d3                    ; Fwd(base,end,inc)
*      adda.l    $0014(a6),a5              ; base+=inc2
*      cmpa.l    $0018(a6),a5              ; end2>base
*      blt.w     @do                        ; for
*
*      movem.l   (a7)+,d4-d7/a3-a5        ; restore registers
*      unlk      a6                        ; remove locals
*      rts                               ; return
*
*      ENDFUNC
*-----
macro
BwdStart0      &addr0,&dAG,&dAH,&dBH
*
*      move.w    (&addr0),d0              ; v=*(short *)addr0
*      move.w    d0,d1                    ; vs=v
*      add.w     d1,d1                    ; vs<=1 (vs=2v)
*      add.w     d1,d0                    ; v+=vs (v=3v)
*      move.w    d0,&dAG                  ; dAG=v3
*      neg.w     &dAG                      ; dAG= -dAG
*      move.w    d0,&dAH                  ; dAH=v
*      add.w     d1,&dAH                  ; dAH+=vs
*      lsl.w     #2,d1                    ; vs<=2 (vs=8v)
*      move.w    d1,&dBH                  ; dBH=vs
*
*      endm
*-----
macro
BwdStart1      &addr1,&addr0,&dAG,&dAH,&dBH
*
*      move.w    (&addr1),d0              ; v=*(short *)addr1
*      move.w    d0,d1                    ; vs=v
*      add.w     d1,d1                    ; vs<=1
*      add.w     d1,&dBH                  ; dBH+=vs
*      add.w     d1,d0                    ; v+=vs (v=3v)
*      lsl.l     #2,d1                    ; vs<=2 (vs=8v)
*      add.w     d1,d0                    ; v+=vs (v=11v)
*      add.w     d0,&dAG                  ; dAG+=v
*      add.w     d1,d0                    ; v+=vs (v=19v)
*      sub.w     d0,&dAH                  ; dAH-=v
*      clr.w     d0                        ; d0=0
*      asr.w     #3,&dBH                  ; dBH>>=3
*      addx.w    d0,&dBH                  ; round dBH
*      move.w    &dBH,(&addr0)           ; *(short *)addr0=dBH
*
*      endm

```

- 720 -

Engineering:KlicsCode:CompPict:ConvolveSH3.a

```

-----
macro
BwdEven &addr2,&dAG,&dAH,&DBG,&dBH

    move.w    (&addr2),d0      ; v=*(short *)addr2
    move.w    d0,d1            ; vs=v
    add.w     d1,d1            ; vs<=1 (vs=2v)
    add.w     d1,d0            ; v+=vs (v=3v)
    move.w    d0,&DBG          ; DBG=v
    neg.w     &DBG             ; DBG=-DBG
    move.w    d0,&dBH          ; dBH=v
    add.w     d1,&dBH          ; dBH+=vs
    lsl.w     #2,d1            ; vs<=2 (vs=8v)
    add.w     d1,d0            ; v+=vs (v=11v)
    add.w     d0,&dAH          ; dAH+=v
    add.w     d1,d0            ; v+=vs (v=19v)
    add.w     d0,&dAG          ; dAG+=v

endm

-----
macro
BwdOdd    &addr3,&addr2,&addr1,&dAG,&dAH,&DBG,&dBH

    move.w    (&addr3),d0      ; v=*(short *)addr3
    move.w    d0,d1            ; vs=v
    add.w     d1,d1            ; vs<=1 (vs=2v)
    add.w     d1,d0            ; v+=vs (v=3v)
    add.w     d0,&dAH          ; dAH+=v
    add.w     d0,&dAG          ; dAG+=v
    add.w     d1,&dAG          ; dAG+=vs
    lsl.w     #2,d1            ; vs<=2 (vs=8v)
    add.w     d1,d0            ; v+=vs (v=11v)
    add.w     d0,&DBG          ; DBG+=v
    add.w     d1,d0            ; v+=vs (v=19v)
    sub.w     d0,&dBH          ; dBH-=v
    clr.w     d0               ; d0=0
    asr.w     #4,&dAH          ; dAH>>=4
    addx.w    d0,&dAH          ; round dAH
    move.w    &dAH,(&addr1)    ; *(short *)addr1=dAH
    asr.w     #4,&dAG          ; dAG>>=4
    addx.w    d0,&dAG          ; round dAG
    move.w    &dAG,(&addr2)    ; *(short *)addr2=dAG

endm

-----
macro
BwdEnd2    &addr2,&dAG,&dAH,&dBH

    move.w    (&addr2),d0      ; v=*(short *)addr2
    move.w    d0,d1            ; vs=v
    add.w     d1,d1            ; vs<=1 (vs=2v)
    add.w     d1,d0            ; v+=vs (v=3v)
    lsl.w     #2,d1            ; vs<=2 (vs=8v)
    move.w    d1,&dBH          ; dBH=vs
    add.w     d1,d0            ; v+=vs (v=11v)
    add.w     d0,&dAH          ; dAH+=v
    add.w     d1,d0            ; v+=vs (v=19v)
    add.w     d0,&dAG          ; dAG+=v

endm

-----
macro
BwdEnd?    &addr?,&addr2,&addr1,&dAG,&dAH,&dBH

```

- 721 -

Engineering:KlicsCode:CompPict:ConvolveSH3.a

```

        move.w    (&addr3),d0    ; v=*(short *)addr3
        move.w    d0,d1          ; vs=v
        add.w     d1,d1          ; vs<=<=1 (vs=2v)
        add.w     d1,d0          ; v+=vs (v=3v)
        add.w     d0,&dAH        ; dAH+=v
        add.w     d0,&dAG        ; dAG+=v
        add.w     d1,&dAG        ; dAG+=vs
        add.w     d1,&dBH        ; dBH+=vs
        lsl.l     #4,d1          ; vs<=<=4 (v=32v)
        sub.w     d1,&dBH        ; dBH-=vs
        clr.w     d0             ; d0=0
        asr.w     #4,&dAH        ; dAH>>=4
        addx.w    d0,&dAH        ; round dAH
        move.w    &dAH,(&addr1)  ; *(short *)addr1=dAH
        asr.w     #4,&dAG        ; dAG>>=4
        addx.w    d0,&dAG        ; round dAG
        move.w    &dAG,(&addr2)  ; *(short *)addr2=dAG
        asr.w     #3,&dBH        ; dBH>>=3
        addx.w    d0,&dBH        ; round dBH
        move.w    &dBH,(&addr3) ; *(short *)addr3=dBH
    endm

-----
macro
Bwd      &base,&end,&inc
*
    movea.l    &base,a0          ; addr0=base
    move.l     &inc,d0           ; d0=inc
    asr.l      #2,d0             ; d0=inc>>2
    movea.l    a0,a3             ; addr3=addr0
    suba.l     d0,a3             ; addr3-=(inc>>2)
    movea.l    a3,a2             ; addr2=addr3
    suba.l     d0,a2             ; addr2-=(inc>>2)
    movea.l    a2,a1             ; addr1=addr2
    suba.l     d0,a1             ; addr1-=(inc>>2)
    BwdStart0  a0,d4,d5,d7       ; BwdStart0(addr0,dAG,dAH,dBH)
    adda.l     &inc,a1           ; addr1+=inc
    BwdStart1  a1,a0,d4,d5,d7    ; BwdStart1(addr1,addr0,dAG,dAH,dBH)
    adda.l     &inc,a2           ; addr2+=inc
    @do
    BwdEven    a2,d4,d5,d6,d7    ; BwdEven(addr2,dAG,dAH,dBG,dBH)
    adda.l     &inc,a3           ; addr3+=inc
    BwdOdd     a3,a2,a1,d4,d5,d6,d7 ; BwdOdd(addr3,addr2,addr1,dAG,dAH,dBG)
    adda.l     &inc,a0           ; addr0+=inc
    BwdEven    a0,d6,d7,d4,d5    ; BwdEven(addr0,dBG,dBH,dAG,dAH)
    adda.l     &inc,a1           ; addr1+=inc
    BwdOdd     a1,a0,a3,d6,d7,d4,d5 ; BwdOdd(addr1,addr0,addr3,dBG,dBH,dAG)
    adda.l     &inc,a2           ; addr2+=inc
    cmpa.l     a2,&end          ; addr2<end
    bgt        @do              ; while
    BwdEnd2    a2,d4,d5,d7       ; BwdEnd2(addr2,dAG,dAH,dBH)
    adda.l     &inc,a3           ; addr3+=inc
    BwdEnd3    a3,a2,a1,d4,d5,d7 ; BwdEnd3(addr3,addr2,addr1,dAG,dAH,dB
    endm

-----
FastBackward    FUNC    EXPORT
*
    link         a6,#0        ; no local variables
    movem.l     d4-d7/a3-a5,-(a7) ; store registers

    move.l      $000C(a6),d3   ; inc=inc1
    movea.l     $0008(a6),a5   ; base=data

```

- 722 -

Engineering:KlicsCode:CompPict:ConvoiveSH3.a

```
@do      movea.l    a5,a4                ; end=base
         adda.l     $0010(a6),a4          ; end+=endl
         Bwd        a5,a4,d3              ; Bwd(base,end,inc)
         adda.l     $0014(a6),a5          ; base+=inc2
         cmpa.l     $0018(a6),a5          ; end2>base
         blt.w      @do                   ; for
.
         movem.l    (a7)+,d4-d7/a3-a5     ; restore registers
         unlk       a6                   ; remove locals
         rts        ; return
.
         ENDFUNC
-----
         END
```

- 723 -

Engineering:KlicsCode:CompPict:Colour.c

```

/******
 *
 *  © Copyright 1993 KLICS Limited
 *  All rights reserved.
 *
 *  Written by: Adrian Lewis
 *
 *****/
/*
 *  Test versions of colour space conversions in C
 */

#include <Memory.h>
#include <QuickDraw.h>

#define NewPointer(ptr,type,size) \
    saveZone=GetZone(); \
    SetZone(SystemZone()); \
    if (nil==(ptr=(type)NewPtr(size))) { \
        SetZone(ApplicZone()); \
        if (nil==(ptr=(type)NewPtr(size))) { \
            SetZone(saveZone); \
            return(MemoryError()); \
        } \
    } \
    SetZone(saveZone);

typedef union {
    long    pixel;
    char    rgb[4];
} Pixel;

/* Special YUV space version */
#define rgb_yuv(pixmap,Yc) \
    pixel.pixel=0x808080^*pixmap++; \
    r=(short)pixel.rgb[1]; \
    g=(short)pixel.rgb[2]; g+=g; \
    b=(short)pixel.rgb[3]; \
    Y=(b<<3)-b; \
    g+=r; \
    Y+=g+g+g; \
    Y>>=4; \
    Y-=g; \
    *Yc++=Y; \
    Y>>=2; \
    U+=b-Y; \
    V+=r-Y;

#define limit(Y,low,high) \
    Y<(low<<2)?low<<2:Y>(high<<2)?high<<2:Y

/* Standard YUV space version - Bt294 CR07(0) mode limiting */
#define rgb_yuv32(pixmap,Yc) \
    pixel.pixel=0x808080^*pixmap++; \
    r=(long)pixel.rgb[1]; \
    g=(long)pixel.rgb[2]; \
    b=(long)pixel.rgb[3]; \
    Y= (306*r + 601*g + 117*b)>>8; \
    *Yc++ = limit(Y,16-128,235-128); \
    U+= (512*r - 429*g - 83*b)>>8; \
    V+= (-173*r - 339*g + 512*b)>>8;

void    RGB2YUV32(long *pixmap, short *Yc, short *Uc, short *Vc, int area, int wid

```

Engineering:KlicsCode:CompPict:Colour.c

```

{
    long    *pixmap2=pixmap+cols, *row, *end=pixmap+area;
    short    *Yc2=Yc+width;

    while(pixmap<end) {
        row=pixmap+width;
        while(pixmap<row) {
            Pixel    pixel;
            long      r,g,b,Y,U=0,V=0;

            rgb_yuv32(pixmap,Yc);
            rgb_yuv32(pixmap,Yc);
            rgb_yuv32(pixmap2,Yc2);
            rgb_yuv32(pixmap2,Yc2);
            U>>=2;
            V>>=2;
            *Uc++=limit(U,16-128,240-128);
            *Vc++=limit(V,16-128,240-128);
        }
        pixmap+=cols+cols-width;
        pixmap2+=cols+cols-width;
        Yc+=width;
        Yc2+=width;
    }
}

typedef struct {
    short    ry, rv, by, bu;
} RGB_Tab;

OSErr RGBTable(long **tab)
{
    RGB_Tab *table;
    int      i;
    THz      saveZone;

    NewPointer(table,RGB_Tab*,256*sizeof(RGB_Tab));
    *tab=(long *)table;
    for(i=0;i<128;i++) {
        table[i].ry=306*i>>8;
        table[i].rv=173*i>>8;
        table[i].by=117*i>>8;
        table[i].bu=83*i>>8;
    }
    for(i=128;i<256;i++) {
        table[i].ry=306*(i-256)>>8;
        table[i].rv=173*(i-256)>>8;
        table[i].by=117*(i-256)>>8;
        table[i].bu=83*(i-256)>>8;
    }
    return(noErr);
}

typedef struct {
    short    ru, gu, bv, gv;
} UV32_Tab;

UV32_Tab *UV32_Table()
{
    UV32_Tab *table;
    int      i;

    table=(UV32_Tab *)NewPtr(256*sizeof(UV32_Tab));
}

```

Engineering:KlicsCode:CompPict:Colour.c

```

    for(i=0;i<128;i++) {
        table[i].ru=128+(1436*i>>10);
        table[i].gu=128+(-731*i>>10);
        table[i].bv=128+(1815*i>>10);
        table[i].gv=-352*i>>10;
    }
    for(i=128;i<256;i++) {
        table[i].ru=128+(1436*(i-256)>>10);
        table[i].gu=128+(-731*(i-256)>>10);
        table[i].bv=128+(1815*(i-256)>>10);
        table[i].gv=-352*(i-256)>>10;
    }
    return(table);
}

typedef struct {
    long    u, v;
} UV32Tab;

OSErr  UV32Table(long **tab)
{
    long    *ytab;
    UV32Tab *uvtab;
    int     i;
    THz     saveZone;

    NewPointer(*tab, long*, 512*sizeof(long)+512*sizeof(UV32Tab));
    ytab=*tab;
    uvtab=(UV32Tab*)&ytab[512];
    for(i=-256;i<256;i++) {
        long    yyy, sp;

        sp=0x000000fe&(i<-128?0:i>127?255:i+128);
        yyy=sp; yyy<<=8;
        yyy|=sp; yyy<<=8;
        yyy|=sp;
        ytab[0x000001ff&i]=yyy;
    }
    for(i=-256;i<256;i++) {
        long    ru,gu,bv,gv;

        ru=0xffffffff&(1436*i>>10);
        gu=0x000001fe&(-731*i>>10);
        bv=0x000001fe&(1815*i>>10);
        gv=0x000001fe&(-352*i>>10);

        uvtab[0x000001ff&i].u=((ru<<8)|gu)<<8;
        uvtab[0x000001ff&i].v=(gv<<8)|bv;
    }
    return(noErr);
}

typedef struct {
    short    u, v;
} UV16Tab;

OSErr  UV16Table(long **tab)
{
    short    *ytab;
    UV16Tab *uvtab;
    int     i;
    THz     saveZone;

```



- 726 -

Engineering:KlicsCode:CompPict:Colour.c

```

NewPointer(*tab, long*, 512*sizeof(short)+512*sizeof(UV16Tab));
ytab=*(short **)tab;
uvtab=(UV16Tab*)&ytab[512];
for(i=-256;i<256;i++) {
    long    yyy, sp;

    sp=0x0000001e&((i<-128?0:i>127?255:i+128)>>3);
    yyy=sp; yyy<=5;
    yyy!=sp; yyy<=5;
    yyy!=sp;
    ytab[0x000001ff&i]=yyy;
}
for(i=-256;i<256;i++) {
    long    ru,gu,bv,gv;

    ru=0xffffffff&(1436*i>>13);
    gu=0x0000003e&(-731*i>>13);
    bv=0x0000003e&(1815*i>>13);
    gv=0x0000003e&(-352*i>>13);

    uvtab[0x000001ff&i].u=((ru<<5)|gu)<<5;
    uvtab[0x000001ff&i].v=(gv<<5)|bv;
}
return(noErr);
}

#define over(val) \
    ((0xFF00&(val)) == 0)?(char)val:val<0?0:255

/* Standard YUV space version */
#define yuv_rgb32(pixmap,Yc) \
    Y=(*Yc++)>>2; \
    pixel.rgb[1]=over(Y+r); \
    pixel.rgb[2]=over(Y+g); \
    pixel.rgb[3]=over(Y+b); \
    *pixmap++=pixel.pixel;

void    YUV2RGB32(long *pixmap, short *Yc, short *Uc, short *Vc, int area, int wid
{
    long    *pixmap2=pixmap+cols, *row, *end=pixmap+area;
    short    *Yc2=Yc+width;

    while(pixmap<end) {
        row=pixmap+width;
        while(pixmap<row) {
            Pixel    pixel;
            long    r,g,b,Y,U,V;

            U=(*Uc++)>>2;
            V=(*Vc++)>>2;
            r=128+(1436*U>>10);
            g=128+(-731*U - 352*V>>10);
            b=128+(1815*V>>10);

            yuv_rgb32(pixmap,Yc);
            yuv_rgb32(pixmap,Yc);
            yuv_rgb32(pixmap2,Yc2);
            yuv_rgb32(pixmap2,Yc2);
        }
        pixmap+=cols+cols-width;
        pixmap2+=cols+cols-width;
        Yc+=width;
    }
}

```

- 727 -

Engineering:KlicsCode:CompPict:Colour.c

```

        Yc2+=width;
    }
}

#define rgb32_yuv(pixmap,Yc) \
    pixel.pixel=0x808080~*pixmap++; \
    r=pixel.rgb[1]; \
    g=pixel.rgb[2]; \
    b=pixel.rgb[3]; \
    Y= (table[0xFF&r].ry + (g<<2)-table[0xFF&g].ry-table[0xFF&g].by + table[0xFF&b] \
    *Yc++ = limit(Y,16-128,235-128); \
    U+= (r<<1) -g -table[0xFF&g].rv - table[0xFF&b].bu; \
    V+= (b<<1) -g -table[0xFF&r].rv - table[0xFF&g].bu;

void RGB32YUV(RGB_Tab *table,long *pixmap, short *Yc, short *Uc, short *Vc, int
{
    long *pixmap2=pixmap+cols, *row, *end=pixmap+area;
    short *Yc2=Yc+width;

    while(pixmap<end) {
        row=pixmap+width;
        while(pixmap<row) {
            Pixel pixel;
            long r,g,b,Y,U=0,V=0;

/*      rgb32_yuv(pixmap,Yc);*/
            pixel.pixel=0x808080~*pixmap++;
            r=pixel.rgb[1];
            g=pixel.rgb[2];
            b=pixel.rgb[3];
            Y= (table[0xFF&r].ry + (g<<2)-table[0xFF&g].ry-table[0xFF&g].by + tabl
            *Yc++ = limit(Y,16-128,235-128);
            U+= (r<<1) -g -table[0xFF&g].rv - table[0xFF&b].bu;
            V+= (b<<1) -g -table[0xFF&r].rv - table[0xFF&g].bu;

            rgb32_yuv(pixmap,Yc);
            rgb32_yuv(pixmap2,Yc2);
            rgb32_yuv(pixmap2,Yc2);
            U>=2;
            V>=2;
            *Uc++=limit(U,16-128,240-128);
            *Vc++=limit(V,16-128,240-128);
        }
        pixmap+=cols+cols-width;
        pixmap2+=cols+cols-width;
        Yc+=width;
        Yc2+=width;
    }
}

#define yuv_rgb32x2(pixmap,Y) \
    pixel.rgb[1]=over(Y+r); \
    pixel.rgb[2]=over(Y+g); \
    pixel.rgb[3]=over(Y+b); \
    pixmap[cols]=pixel.pixel; \
    *pixmap++=pixel.pixel;

void YUV2RGB32x2(UV32_Tab *table,long *pixmap, short *Yc, short *Uc, short *Vc,
{
    long *pixmap2=pixmap+2*cols, *row, *end=pixmap+area;
    short *Yc2=Yc+width;

```

Engineering:KlicsCode:CompPict:Colour.c

```

while(pixmap<end) {
    long    Yold=*Yc>>2, Yold2=*Yc2>>2;

    row=pixmap+width*2;
    while(pixmap<row) {
        Pixel    pixel;
        long      r,g,b,Y,U,V;

        U=0x00FF&((*Uc++)>>2);
        V=0x00FF&((*Vc++)>>2);
        r=table[U].ru;
        g=table[U].gu+table[V].gv;
        b=table[V].bv;

        Y=(*Yc++)>>2;
        Yold=(Y+Yold)>>1;
        yuv_rgb32x2(pixmap,Yold);

        Yold=Y;
        yuv_rgb32x2(pixmap,Yold);

        Y=(*Yc++)>>2;
        Yold=(Y+Yold)>>1;
        yuv_rgb32x2(pixmap,Yold);

        Yold=Y;
        yuv_rgb32x2(pixmap,Yold);

        Y=(*Yc2++)>>2;
        Yold2=(Y+Yold2)>>1;
        yuv_rgb32x2(pixmap2,Yold2);

        Yold2=Y;
        yuv_rgb32x2(pixmap2,Yold2);

        Y=(*Yc2++)>>2;
        Yold2=(Y+Yold2)>>1;
        yuv_rgb32x2(pixmap2,Yold2);

        Yold2=Y;
        yuv_rgb32x2(pixmap2,Yold2);
    }
    pixmap+=4*cols-2*width;
    pixmap2+=4*cols-2*width;
    Yc+=width;
    Yc2+=width;
}

#define yuv_rgb8(pixel,Yc,index,dith) \
    Y=*Yc++; \
    Y<=3; \
    Y&= 0x3F00; \
    Y|= U; \
    pixel.rgb[index]=table[Y].rgb[dith];

void    YUV2RGB8(Pixel *table,long *pixmap, short *Yc, short *Uc, short *Vc, int a
{
    long    *pixmap2=pixmap+cols/4, *row, *end=pixmap+area/4;
    short    *Yc2=Yc+width;

    while(pixmap<end) {

```

- 729 -

Engineering:KlicsCode:CompPict:Colour.c

```

row=pixmap+width/4;
while(pixmap<row) {
    Pixel    pixel, pixel2;
    long      Y,U,V;

    U=*Uc++;
    V=*Vc++;
    U>>=2;
    V>>=6;
    U= (U&0xF0) | (V&0x0F);

    yuv_rgb8(pixel,Yc,0,3);
    yuv_rgb8(pixel,Yc,1,0);
    yuv_rgb8(pixel2,Yc2,0,1);
    yuv_rgb8(pixel2,Yc2,1,2);

    U=*Uc++;
    V=*Vc++;
    U>>=2;
    V>>=6;
    U= (U&0xF0) | (V&0x0F);

    yuv_rgb8(pixel,Yc,2,3);
    yuv_rgb8(pixel,Yc,3,0);
    yuv_rgb8(pixel2,Yc2,2,1);
    yuv_rgb8(pixel2,Yc2,3,2);

    *pixmap++=pixel.pixel;
    *pixmap2++=pixel2.pixel;
}
pixmap+=(cols+cols-width)/4;
pixmap2+=(cols+cols-width)/4;
Yc+=width;
Yc2+=width;
}

#define yuv_rgb8x2(pixel,pixel2,Y,index,dith,dith2) \
    Y&= 0x3F00; \
    Y|= U; \
    pixel.rgb[index]=table[Y].rgb[dith]; \
    pixel2.rgb[index]=table[Y].rgb[dith2];

void    YUV2RGB8x2(Pixel *table,long *pixmap, short *Yc, short *Uc, short *Vc, int
{
    long    *pixmap2=pixmap+cols/2, *row, *end=pixmap+area/4;
    short    *Yc2=Yc+width;

    while(pixmap<end) {
        long    Yold=*Yc<<3, Yold2=*Yc2<<3;

        row=pixmap+width/2;
        while(pixmap<row) {
            Pixel    pixel, pixel2, pixel3, pixel4;
            long      Y,U,V;

            U=*Uc++;
            V=*Vc++;
            U>>=2;
            V>>=6;
            U= (U&0x00F0) | (V&0x000F);

            Y=(*Yc++)<<3;

```

- 730 -

Engineering:KlicsCode:CompPict:Colour.c

```

    Yold=(Y+Yold)>>1;
    yuv_rgb8x2(pixel,pixel2,Y,0,3,1);

    Yold=Y;
    yuv_rgb8x2(pixel,pixel2,Y,1,0,2);
    Yold=Y;

    Y=(*Yc++)<<3;
    Yold=(Y+Yold)>>1;
    yuv_rgb8x2(pixel,pixel2,Y,2,3,1);

    Yold=Y;
    yuv_rgb8x2(pixel,pixel2,Y,3,0,2);
    Yold=Y;

    Y=(*Yc2++)<<3;
    Yold2=(Y+Yold2)>>1;
    yuv_rgb8x2(pixel3,pixel4,Y,0,3,1);

    Yold2=Y;
    yuv_rgb8x2(pixel3,pixel4,Y,1,0,2);
    Yold2=Y;

    Y=(*Yc2++)<<3;
    Yold2=(Y+Yold2)>>1;
    yuv_rgb8x2(pixel3,pixel4,Y,2,3,1);

    Yold2=Y;
    yuv_rgb8x2(pixel3,pixel4,Y,3,0,2);
    Yold2=Y;

    pixmap[cols/4]=pixel2.pixel;
    *pixmap++=pixel.pixel;

    pixmap2[cols/4]=pixel4.pixel;
    *pixmap2++=pixel3.pixel;
}
pixmap+=(cols+cols-width)/2;
pixmap2+=(cols+cols-width)/2;
Yc+=width;
Yc2+=width;
}

#define yuv_rgbTEST(pixel,index,Y) \
    rgb_col.red=(Y+r<<8); \
    rgb_col.green=(Y+g<<8); \
    rgb_col.blue=(Y+b<<8); \
    pixel.rgb[index]=Color2Index(&rgb_col);

void YUV2RGBTEST(UV32_Tab *table,long *pixmap, short *Yc, short *Uc, short *Vc,
{
    long *pixmap2=pixmap+cols/2, *row, *end=pixmap+area/4;
    short *Yc2=Yc+width;

    while(pixmap<end) {
        long Yold=*Yc<<3, Yold2=*Yc2<<3;

        row=pixmap+width/2;
        while(pixmap<row) {
            RGBColor rgb_col;
            Pixel pixel, pixel2;

```

- 731 -

Engineering:KlicsCode:CompPict:Colour.c

```

long    r,g,b,Y,U,V;

U=0x00FF&((*Uc++)>>2);
V=0x00FF&((*Vc++)>>2);
r=table[U].ru;
g=table[U].gu+table[V].gv;
b=table[V].bv;

Y=(*Yc++)>>2;
Yold=(Y+Yold)>>1;
rgb_col.red=(Yold+r<<8);
rgb_col.green=(Yold+g<<8);
rgb_col.blue=(Yold+b<<8);
pixel.rgb[0]=Color2Index(&rgb_col);

Yold=Y;
yuv_rgbTEST(pixel,1,Yold);

Y=(*Yc++)>>2;
Yold=(Y+Yold)>>1;
yuv_rgbTEST(pixel,2,Yold);

Yold=Y;
yuv_rgbTEST(pixel,3,Yold);

Y=(*Yc2++)>>2;
Yold2=(Y+Yold2)>>1;
yuv_rgbTEST(pixel2,0,Yold2);

Yold2=Y;
yuv_rgbTEST(pixel2,1,Yold2);

Y=(*Yc2++)>>2;
Yold2=(Y+Yold2)>>1;
yuv_rgbTEST(pixel2,2,Yold2);

Yold2=Y;
yuv_rgbTEST(pixel2,3,Yold2);

pixmap[cols/4]=pixel.pixel;
*pixmap++=pixel.pixel;

pixmap2[cols/4]=pixel2.pixel;
*pixmap2++=pixel2.pixel;
}
pixmap+=(cols+cols-width)/2;
pixmap2+=(cols+cols-width)/2;
Yc+=width;
Yc2+=width;
}

```

- 732 -

Engineering:KlicsCode:CompPict:Colour.a

```

-----
*
*   © Copyright 1993 KLICS Limited
*   All rights reserved.
*
*   Written by: Adrian Lewis
*
-----
*
*   68030 Colour space conversions
*
-----
*
*   machine mc68030
*   seg      'klics'
*   include  'Traps.a'
*
-----
*
*   macro
*   DPY32x2      &ARGB, &row, &o0, &o1, &n0, &n1
*
*       add.l      &n0,&o0
*       lsr.l      #1,&o0
*       add.l      &n1,&o1
*       lsr.l      #1,&o1
*
*           ; interpolate first pixel
*           ; interpolate first pixel
*
*       move.l     &o0,(&ARGB)
*       add.l      &row,&ARGB
*       move.l     &o0,(&ARGB)
*       add.l      &row,&ARGB
*       move.l     &o1,(&ARGB)
*       add.l      &row,&ARGB
*       move.l     &o1,(&ARGB)+
*
*       move.l     &n1,(&ARGB)
*       sub.l      &row,&ARGB
*       move.l     &n1,(&ARGB)
*       sub.l      &row,&ARGB
*       move.l     &n0,(&ARGB)
*       sub.l      &row,&ARGB
*       move.l     &n0,(&ARGB)+
*
*   endm
*
-----
*
*   macro
*   DPY32      &ARGB, &row, &o0, &o1, &n0, &n1
*
*       move.l     &o0,(&ARGB)
*       add.l      &row,&ARGB
*       move.l     &o1,(&ARGB)+
*
*       move.l     &n1,(&ARGB)
*       sub.l      &row,&ARGB
*       move.l     &n0,(&ARGB)+
*
*   endm
*
-----
*
*   macro
*   UV2RGB32      &AU,&AV,&TAB
*
*       add.l      #2048,&TAB
*
*           ; move to uvtab
*
*       move.w     &AU,d1
*       lsr.w      #2,d1
*       and.w      #501FF,d1
*
*           ; Load U

```

- 733 -

Engineering:KlicsCode:CompPict:Colour.a

```

        move.l    (&TAB,d1.w*8),d0      ; UV now rg (u)

        move.w    &AV,d1                ; Load V
        lsr.w     #2,d1
        and.w     #$01FF,d1
        add.l     4(&TAB,d1.w*8),d0      ; UV now rgb

        move.l    d0,d1                  ; 3 copies
        move.l    d0,d2
        move.l    d0,d3

        sub.l     #2048,&TAB              ; restore ytab
*
        endm
*-----
        macro
GETY32      &AY, &TAB, &RGB0, &RGB1
*
        move.l    &AY,d4                  ;Y
        lsr.w     #2,d4
        and.w     #$01FF,d4
        add.l     (&TAB,d4.w*4),&RGB1    ; RGB1+=YYY

        swap      d4
        lsr.w     #2,d4
        and.w     #$01FF,d4
        add.l     (&TAB,d4.w*4),&RGB0    ; RGB0+=YYY
*
        endm
*-----
        macro
OVER32      &RGB
*
        move.l    &RGB,d4                ; copy pixel
        andi.l    #$01010100,d4          ; was it this rgb
        beq.s     @nx_rgb                 ; if not then quit
        btst      #24,d4                  ; R overflow?
        beq.s     @bit16                  ; if not then continue
        btst      #23,&RGB                 ; test sign
        beq.s     @pos23                  ; if positive
        andi.l    #$0000ffff,&RGB         ; underflow sets R to 0
        bra.s     @bit16                  ; do next bit
@pos23      ori.l  #$00ff0000,&RGB         ; overflow sets R to 255
@bit16      btst  #16,d4                  ; G overflow?
        beq.s     @bit8                   ; if not then continue
        btst      #15,&RGB                 ; test sign
        beq.s     @pos16                  ; if positive
        andi.w    #$00ff,&RGB             ; underflow sets G to 0
        bra.s     @bit8                   ; do next bit
@pos16      ori.w  #$ff00,&RGB             ; overflow sets G to 255
@bit8       btst  #8,d4                   ; B overflow?
        beq.s     @end                    ; if not then continue
        btst      #7,&RGB                  ; test sign
        seq       &RGB                    ; under/over flow
@end        andi.l #$00fefefe,&RGB         ; mask RGB ok
@nx_rgb
*
        endm
*-----
        macro
HASHOUT32   &AH, &D0, &D1, &D2, &D3
*
        move.l    &D0,d4

```



- 734 -

Engineering:KlicsCode:CompPict:Colour.a

```

        add.l    &D1,d4
        add.l    &D2,d4
        add.l    &D3,d4
        andi.l   #$03e3e3e0,d4
        move.l   d4,&AH
    .
    .-----
    .
    .macro
    .HASHCMP32    &AH, &D0, &D1, &D2, &D3
    .
    .    move.l   &D0,d4
    .    add.l    &D1,d4
    .    add.l    &D2,d4
    .    add.l    &D3,d4
    .    andi.l   #$03e3e3e0,d4
    .    cmp.l    &AH,d4
    .
    .endm
    .-----
    .
    .OUT32X2 FUNC      EXPORT
    .
    .PS          RECORD      8
    .table       DS.L        1
    .pixmap      DS.L        1
    .Y           DS.L        1
    .U           DS.L        1
    .V           DS.L        1
    .width       DS.L        1
    .height      DS.L        1
    .rowByte     DS.L        1
    .pixmap2     DS.L        1
    .            ENDR
    .
    .LS          RECORD      0,DECR
    .Y1          DS.L        1
    .U_ex        DS.L        1
    .U_ey        DS.L        1
    .U_ix        DS.L        1
    .Y_Y         DS.L        1
    .P_Y         DS.L        1
    .LSize       EQU         *
    .            ENDR
    .
    .a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
    .d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - old0, d7
    .
    .link        a6,#LS.LSize
    .movem.l     d4-d7/a3-a5,-(a7)
    .            ; inc, width, fend and rowend are loca
    .            ; store registers
    .
    .move        SR,d0
    .
    .move.l      PS.Y(a6),a0
    .move.l      PS.U(a6),a1
    .move.l      PS.V(a6),a2
    .move.l      PS.pixmap(a6),a3
    .move.l      PS.table(a6),a4
    .move.l      PS.pixmap2(a6),a5
    .            ; Y=Yc
    .            ; U=Uc
    .            ; V=Vc
    .            ; pm=pixmap
    .            ; tab=table
    .            ; pm2=pixmap2
    .
    .move.l      PS.width(a6),d0
    .move.l      d0,LS.U_ix(a6)
    .move.l      PS.height(a6),d1
    .mulu.w      d0,d1
    .            ; LOAD width
    .            ; SAVE U_ix
    .            ; LOAD height
    .            ; width*height

```

- 735 -

Engineering:KlicsCode:CompPict:Colour.a

```

lsr.l    #1,d1
add.l    a1,d1          ; width*height/2
move.l   d1,LS.U_ey(a6) ; U+width*height/2
add.l    d0,d0          ; SAVE U_ey
move.l   d0,LS.Y1(a6)   ; width*2
move.l   d0,LS.Y_y(a6)  ; SAVE Y1
lsr.l    #2,d0          ; width*8
move.l   PS.rowByte(a6),d1 ; LOAD rowBytes
lsr.l    #2,d1          ; rowBytes*4
sub.l    d0,d1          ; rowBytes*4-width*8
move.l   d1,LS.P_y(a6)  ; SAVE P_y

move.l   PS.rowByte(a6),d5 ; load rowBytes
clr.l    d6             ; clear old2
clr.l    d7             ; clear old1

@do_y    move.l   LS.U_ix(a6),d0 ; LOAD U_ixB
add.l    a1,d0          ; P+U_ixB
move.l   d0,LS.U_ex(a6) ; SAVE U_exB

@do_x    UV2RGB32      (a1)+,(a2)+,a4 ; uv2rgb(*U++,*V++)

move.l   LS.Y1(a6),d4    ; load Yrow
GETY32   (a0,d4.1),a4,d2,d3 ; add Yb to RGB values
GETY32   (a0)+,a4,d0,d1 ; add Ya to RGB values

move.l   d0,d4
or.l     d1,d4
or.l     d2,d4
or.l     d3,d4
andi.l   #01010100,d4
bne.s    @over          ; if overflow

@ok      HASHOUT32      (a5)+,d0,d1,d2,d3

DPY32x2  a3,d5,d6,d7,d0,d2
DPY32x2  a3,d5,d0,d2,d1,d3

move.l   d1,d6
move.l   d3,d7          ; copy olds

cmpa.l   LS.U_ex(a6),a1
blt.w    @do_x

add.l    LS.Y_y(a6),a0
add.l    LS.P_y(a6),a3

cmpa.l   LS.U_ey(a6),a1
blt.w    @do_y

movem.l  (a7)+,d4-d7/a3-a5 ; restore registers
unlk     a6               ; remove locals
rts      ; return

@over    OVER32         d0
OVER32   d1
OVER32   d2
OVER32   d3
bra      @ok

```

ENDFUNC

```

-----
OUT32X2D  FUNC      EXPORT

```

- 736 -

Engineering:KlicsCode:CompPict:Colour.a

```

PS      RECORD      8
table   DS.L         1
pixmap  DS.L         1
Y       DS.L         1
U       DS.L         1
V       DS.L         1
width   DS.L         1
height  DS.L         1
rowByte DS.L         1
pixmap2 DS.L         1
        ENDR
*
LS      RECORD      0,DECR
Yl      DS.L         1
U_ex    DS.L         1      ; sizeof(short)*Yrow      = 2*width
U_ey    DS.L         1      ; x end address      = U+U_ix
U_ix    DS.L         1      ; y end address      = U+width*height>>
Y_y     DS.L         1      ; sizeof(short)*UVrow = width
P_y     DS.L         1      ; sizeof(short)*Yrow  = 2*width
LSize   EQU          *      ; 4*rowBytes-sizeof(long)*Prow = 4*rowBytes-width
        ENDR
*
*      a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
*      d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - old0, d7
*
link     a6,#LS.LSize      ; inc, width, fend and rowend are loca
movem.l  d4-d7/a3-a5,-(a7) ; store registers

move.l   PS.Y(a6),a0      ; Y=Yc
move.l   PS.U(a6),a1      ; U=Uc
move.l   PS.V(a5),a2      ; V=Vc
move.l   PS.pixmap(a6),a3 ; pm=pixmap
move.l   PS.table(a6),a4  ; tab=table
move.l   PS.pixmap2(a6),a5 ; pm2=pixmap2

move.l   PS.width(a6),d0  ; LOAD width
move.l   d0,LS.U_ix(a6)   ; SAVE U_ix
move.l   PS.height(a6),d1 ; LOAD height
mulu.w   d0,d1            ; width*height
lsr.l    #1,d1            ; width*height/2
add.l    a1,d1            ; U+width*height/2
move.l   d1,LS.U_ey(a6)   ; SAVE U_ey
add.l    d0,d0            ; width*2
move.l   d0,LS.Yl(a6)     ; SAVE Yl
move.l   d0,LS.Y_y(a6)    ; SAVE Y_y
lsr.l    #2,d0            ; width!!*8
move.l   PS.rowByte(a6),d1 ; LOAD rowBytes
lsr.l    #2,d1            ; rowBytes*4
sub.l    d0,d1            ; rowBytes*4-width*8
move.l   d1,LS.P_y(a6)    ; SAVE P_y

move.l   PS.rowByte(a6),d5 ; load rowBytes
clr.l    d6              ; clear old2
clr.l    d7              ; clear old1

@do_y    move.l   LS.U_ix(a6),d0 ; LOAD U_ixB
         add.l    a1,d0          ; P+U_ixB
         move.l   d0,LS.U_ex(a6) ; SAVE U_exB

@do_x    UV2RGB32    (a1)+,(a2)+,a4 ; uv2rgb(*U++,*V++)

move.l   LS.Yl(a6),d4      ; load Yrow
GETY32   (a0,d4.1),a4,d2,d3 ; add Yb to RGB values

```

- 737 -

Engineering:KlicsCode:CompPict:Colour.a

```

GETY32      (a0)+,a4,d0,d1      ; add Ya to RGB values

move.l      d0,d4
or.l        d1,d4
or.l        d2,d4
or.l        d3,d4
andi.l      #$01010100,d4
bne.w       @over              ; if overflow

@ok          HASHCMP32 (a5)+,d0,d1,d2,d3
bne.s       @diff

add.l       #16,a3              ; add four pixels

@cont        move.l      d1,d6      ; copy olds
move.l      d3,d7

cmpa.l      LS.U_ex(a6),a1
blt.w       @do_x

add.l       LS.Y_y(a6),a0
add.l       LS.P_y(a6),a3

cmpa.l      LS.U_ey(a6),a1
blt.w       @do_y

movem.l     (a7)+,d4-d7/a3-a5    ; restore registers
unlk        a6                  ; remove locals
rts         ; return

@diff        move.l      d4,-4(a5)
DPY32x2     a3,d5,d6,d7,d0,d2
DPY32x2     a3,d5,d0,d2,d1,d3
bra.s       @cont

@over        OVER32      d0
OVER32      d1
OVER32      d2
OVER32      d3
bra         @ok

*
ENDFUNC
-----
OUT32  FUNC      EXPORT
*
PS      RECORD      8
table   DS.L        1
pixmap  DS.L        1
Y        DS.L        1
U        DS.L        1
V        DS.L        1
width    DS.L        1
height   DS.L        1
rowByte  DS.L        1
pixmap2  DS.L        1
*
LS      RECORD      0,DECR
Y1      DS.L        1
U_ex     DS.L        1      ; sizeof(short)*Yrow      = 2*width
U_ey     DS.L        1      ; x end address          = 0+U_ix
U_ix     DS.L        1      ; y end address          = U+width*height>>
Y_y      DS.L        1      ; sizeof(short)*UVrow    = width
P_y      DS.L        1      ; sizeof(short)*Yrow     = 2*width
LSize    EQU         *      ; 2*rowBytes-sizeof(long)*Prow = 2*rowBytes-width

```

- 738 -

Engineering:KlicsCode:CompPict:Colour.a

```

ENDR
.
.
a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - cld0, d7
.
link      a6,#LS.LSize      ; inc, width, fend and rowend are loca
movem.l   d4-d7/a3-a5,-(a7) ; store registers

move.l    PS.Y(a6),a0      ; Y=Yc
move.l    PS.U(a6),a1      ; U=Uc
move.l    PS.V(a6),a2      ; V=Vc
move.l    PS.pixmap(a6),a3 ; pm=pixmap
move.l    PS.table(a6),a4   ; tab=table
move.l    PS.pixmap2(a6),a5 ; pm2=pixmap2

move.l    PS.width(a6),d0   ; LOAD width
move.l    d0,LS.U_ix(a6)   ; SAVE U_ix
move.l    PS.height(a6),d1 ; LOAD height
mulu.w    d0,d1            ; width*height
lsr.l     #1,d1            ; width*height/2
add.l     a1,d1            ; U+width*height/2
move.l    d1,LS.U_ey(a6)   ; SAVE U_ey
add.l     d0,d0            ; width*2
move.l    d0,LS.Y1(a6)     ; SAVE Y1
move.l    d0,LS.Y_y(a6)    ; SAVE Y_y
add.l     d0,d0            ; width*4
move.l    PS.rowByte(a6),d1 ; LOAD rowBytes
add.l     d1,d1            ; rowBytes*2
sub.l     d0,d1            ; rowBytes*2-width*4
move.l    d1,LS.P_y(a6)    ; SAVE P_y

move.l    PS.rowByte(a6),d5 ; load rowBytes
move.l    LS.Y1(a6),d6      ; load Yrow

@do_y     move.l    LS.U_ix(a6),d7 ; LOAD U_ix3
add.l     a1,d7            ; P+U_ixB

@do_x     UV2RGB32     (a1)+,(a2)+,a4 ; uv2rgb(*U++,*V++)

GETY32    (a0,d6.1),a4,d2,d3 ; add Yb to RGB values
GETY32    (a0)+,a4,d0,d1    ; add Ya to RGB values

move.l    d0,d4
or.l      d1,d4
or.l      d2,d4
or.l      d3,d4
andi.l    #01010100,d4
bne.s     @over            ; if overflow

@ok       HASHOUT32     (a5)+,d0,d1,d2,d3

DPY32     a3,d5,d0,d2,d1,d3

cmpa.l    d7,a1
blt.w     @do_x

add.l     LS.Y_y(a6),a0
add.l     LS.P_y(a6),a3

cmpa.l    LS.U_ey(a6),a1
blt.w     @do_y

movem.l    (a7)+,d4-d7/a3-a5 ; restore registers

```

- 739 -

Engineering:KlicsCode:CompPict:Colour.a

```

        unlk      a6                      ; remove locals
        rts                          ; return
@over   OVER32    d0
        OVER32    d1
        OVER32    d2
        OVER32    d3
        bra       @ok

        ENDFUNC
-----
OUT32D  FUNC      EXPORT
*
PS      RECORD    8
table   DS.L      1
pixmap  DS.L      1
Y       DS.L      1
U       DS.L      1
V       DS.L      1
width   DS.L      1
height  DS.L      1
rowByte DS.L      1
pixmap2 DS.L      1
        ENDR
*
LS      RECORD    0,DECR
Y1      DS.L      1
U_ex    DS.L      1
U_ey    DS.L      1
U_ix    DS.L      1
Y_y     DS.L      1
P_y     DS.L      1
LSize   EQU       *
        ENDR
*
*      a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
*      d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - Yrow, d7
*
link     a6,#LS.LSize
movem.l  d4-d7/a3-a5,-(a7)      ; inc, width, fend and rowend are loca
                                ; store registers ..

move.l   PS.Y(a6),a0           ; Y=Yc
move.l   PS.U(a6),a1           ; U=Uc
move.l   PS.V(a6),a2           ; V=Vc
move.l   PS.pixmap(a6),a3      ; pm=pixmap
move.l   PS.table(a6),a4       ; tab=table
move.l   PS.pixmap2(a6),a5     ; pm2=pixmap2

move.l   PS.width(a6),d0       ; LOAD width
move.l   d0,LS.U_ix(a6)        ; SAVE U_ix
move.l   PS.height(a6),d1      ; LOAD height
mulu.w   d0,d1                 ; width*height
lsr.l    #1,d1                 ; width*height/2
add.l    a1,d1                 ; U+width*height/2
move.l   d1,LS.U_ey(a6)        ; SAVE U_ey
add.l    d0,d0                 ; width*2
move.l   d0,LS.Y1(a6)          ; SAVE Y1
move.l   d0,LS.Y_y(a6)         ; SAVE Y_y
add.l    d0,d0                 ; width*4
move.l   PS.rowByte(a6),d1     ; LOAD rowBytes
add.l    d1,d1                 ; rowBytes*2
sub.l    d0,d1                 ; rowBytes*2-width*4
move.l   d1,LS.P_y(a6)         ; SAVE P_y

```

- 740 -

Engineering:KlicsCode:CompPict:Colour.a

```

        move.l    PS.rowByte(a6),d5        ; load rowBytes
        move.l    LS.Y1(a6),d6            ; load Yrow
@do_y    move.l    LS.U_ix(a6),d7          ; LOAD U_ixB
        add.l     a1,d7                    ; P+U_ixB
@do_x    UV2RGB32    (a1)+,(a2)+,a4        ; uv2rgb(*U++,*V++)

        move.l    LS.Y1(a6),d4            ; load Yrow
        GETY32    (a0,d6.l),a4,d2,d3      ; add Yb to RGB values
        GETY32    (a0)+,a4,d0,d1         ; add Ya to RGB values

        move.l    d0,d4
        or.l      d1,d4
        or.l      d2,d4
        or.l      d3,d4
        andi.l    #01010100,d4
        bne.s     @over                    ; if overflow
@ok      HASHCMP32    (a5)+,d0,d1,d2,d3    @diff
        bne.s     @diff

        addq      #8,a3                    ; add four pixels
@cont    cmpa.l     d7,a1
        blt.w     @do_x

        add.l     LS.Y_y(a6),a0
        add.l     LS.P_y(a6),a3

        cmpa.l     LS.U_ey(a6),a1
        blt.w     @do_y
*
        movem.l    (a7)+,d4-d7/a3-a5      ; restore registers
        unlk      a6                      ; remove locals
        rts
@diff    move.l     d4,-4(a5)
        DPY32     a3,d5,d0,d2,d1,d3
        bra.s     @cont
@over    OVER32    d0
        OVER32    d1
        OVER32    d2
        OVER32    d3
        bra       @ok
*
        ENDFUNC
-----
        macro
        UVOV      &VAL, &OV

*
        move.w     &VAL,&OV
        add.w      #0200,&OV
        and.w      #0FC00,&OV
        beq.s      @ok
        tst.w      &OV
        bge.s      @pos
        move.w     #01FF,&VAL
        bra.s      @ok
@pos      move.w     #0FE00,&VAL
@ok
*
        endm

```

- 741 -

Engineering:KlicsCode:CompPict:Colour.a

```

UVLIMIT FUNC      EXPORT
* fix d0, d4, spare d1 d2
    UVOV          d0,d1
    swap          d0
    UVOV          d0,d1
    swap          d0
    UVOV          d4,d1
    swap          d4
    UVOV          d4,d1
    swap          d4
    rts
*
    ENDFUNC

    macro
    UVOVER          &U, &V

    move.l         #$02000200,d1
    move.l         d1,d2
    add.l          &U,d1
    add.l          &V,d2
    or.l           d2,d1
    andi.l         #SFC00FC00,d1
    beq.s          @UVok
    bsr            UVLIMIT
@UVok
    endm

    macro
    GETUV           &AU, &AV, &SP, &UV

    move.l         (&AU)+,&SP
    move.l         (&AV)+,&UV
    UVOVER         &SP,&UV
    lsr.l          #5,&UV
    andi.l         #03e003e0,&SP
    andi.l         #001f001f,&UV
    or.l           &SP,&UV
    swap          &UV
    ; UV==000UV00UV

    endm

    macro
    GETY            &AY,&IND,&UV,&R0,&R1

    move.l         &AY,&R1
    lsl.l          #5,&R1
    andi.l         #SFC00FC00,&R1
    or.w           &UV,&R1
    move.l         (&IND,&R1 .w*4),&R0
    swap          &R1
    or.w           &UV,&R1
    move.l         (&IND,&R1 .w*4),&R1
    ; (2+) Y=Y0Y1
    ; (4) Y=Y0XXY1XX
    ;
    ; (2) Y=Y1UV
    ; (2+) R0=0123 (Y1)
    ; (4) Y=Y0XX
    ; (2) Y=Y0UV
    ; (2+) R1=0123 (Y0)

    endm

    macro
    UV8             &AU, &AV, &SP, &UV

    move.l         (&AU)+,&SP
    move.l         (&AV)+,&UV
    UVOVER         &SP,&UV

```



- 742 -

Engineering:KlicsCode:CompPict:Colour.a

```

lsr.l      #2,&SP
lsr.l      #6,&UV
andi.l     #S00F000F0,&SP
andi.l     #S000F000F,&UV
or.l       &SP,&UV          ; UV==S00UV00UV
swap       &UV

endm

macro
Y?IND      &Y,&IND,&UV,&D0,&D1

move.l     &Y,&D0          ; d0=Y0Y1
lsl.l      #3,&D0          ; d0=Y0XXY1XX
move.b     &UV,&D0          ; d0=Y0XXY1UV
andi.w     #S3FFF,&D0      ; d0=0YUV(1)
move.l     (&IND,&D0 .w*4),&D1 ; find clut entries
swap       &D0            ; d0=Y0XX
move.b     &UV,&D0          ; d0=Y0UV
andi.w     #S3FFF,&D0      ; d0=0YUV(0)
move.l     (&IND,&D0 .w*4),&D0 ; find clut entries

endm

OUT8      FUNC      EXPORT
*
PS        RECORD      8
table     DS.L        1
pixmap    DS.L        1
Y         DS.L        1
U         DS.L        1
V         DS.L        1
width     DS.L        1
height    DS.L        1
rowByte    DS.L        1
pixmap2   DS.L        1
ENDR
*
LS        RECORD      0,DECR
Y1        DS.L        1          ; sizeof(short)*Yrow          = 2*width
U_ex      DS.L        1          ; x end address          = U+U_ix
U_ey      DS.L        1          ; y end address          = U+width*height>>
U_ix      DS.L        1          ; sizeof(short)*UVrow    = width
Y_y       DS.L        1          ; sizeof(short)*Yrow    = 2*width
P_y       DS.L        1          ; 2*rowBytes-sizeof(long)*Prow = 2*rowBytes-width
LSize     EQU          *
ENDR
*
a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - old0, d7

link       a6,#LS.LSize
movem.l    d4-d7/a3-a5,-(a7)    ; inc, width, fend and rowend are local
; store registers

move.l     PS.Y(a6),a0          ; Y=Yc
move.l     PS.U(a6),a1          ; U=Uc
move.l     PS.V(a6),a2          ; V=Vc
move.l     PS.pixmap(a6),a3     ; pm=pixmap
move.l     PS.table(a6),a4      ; tab=table
adda.l     #S00020000,a4        ; tab+=32768 (longs)
move.l     PS.pixmap2(a6),a5    ; pm2=pixmap2

move.l     PS.width(a6),d0      ; LOAD width

```

- 743 -

Engineering:KlicsCode:CompPict:Colour.a

```

move.l    d0,LS.U_ix(a6)          ; SAVE U_ix
move.l    PS.height(a6),d1        ; LOAD height
mulu.w    d0,d1                   ; width*height
lsr.l     #1,d1                   ; width*height/2
add.l     a1,d1                   ; U+width*height/2
move.l    d1,LS.U_ey(a6)          ; SAVE U_ey
move.l    PS.rowByte(a6),d1       ; LOAD rowBytes
add.l     d1,d1                   ; rowBytes*2
sub.l     d0,d1                   ; rowBytes*2-width
move.l    d1,LS.P_y(a6)           ; SAVE P_y
add.l     d0,d0                   ; width*2
move.l    d0,LS.Y1(a6)            ; SAVE Y1
move.l    d0,LS.Y_y(a6)           ; SAVE Y_y

move.l    PS.rowByte(a6),d5        ; load rowBytes
move.l    LS.Y1(a6),d6            ; load Yrow

@do_y     move.l    LS.U_ix(a6),d7    ; LOAD U_ixB
add.l     a1,d7                  ; P+U_ixB

@do_x     GETUV      a1,a2,d0,d4

GETY      (a0,d6.w),a4,d4,d2,d3    ; d2=X0XX, d3=XX1X
GETY      (a0)+,a4,d4,d0,d1       ; d0=XXX0, d1=1XXX

move.w    d3,d2                  ; d2=X01X
lsl.l     #8,d2                  ; d2=01XX
move.w    d0,d1                  ; d1=1XX0
swap      d1                     ; d1=X01X
lsl.l     #8,d1                  ; d1=01XX

swap      d4                      ; next UV

GETY      (a0,d6.l),a4,d4,d0,d3    ; d0=X2XX, d3=XX3X
move.w    d3,d0                  ; d0=X23X
lsr.l     #8,d0                  ; d0=XX23
move.w    d0,d2                  ; d2=0123
GETY      (a0)+,a4,d4,d0,d3       ; d0=XXX2, d3=3XXX
move.w    d0,d3                  ; d3=3XX2
swap      d3                     ; d3=X23X
lsr.l     #8,d3                  ; d3=XX23
move.w    d3,d1                  ; d1=C123

move.l    d2,(a3,d5)
move.l    d1,(a3)+

cmpa.l    d7,a1
blt.w     @do_x

add.l     LS.Y_y(a6),a0
add.l     LS.P_y(a6),a3

cmpa.l    LS.U_ey(a6),a1
blt.w     @do_y

movem.l   (a7)+,d4-d7/a3-a5        ; restore registers
unlk      a6                      ; remove locals
rts       ; return

ENDFUNC
-----
macro
Y8x2      &AY,&IND,&UV,&old

```

Engineering:KlicsCode:CompPict:Colour.a

```

move.l    &AY,d0                ; (2+) Y=Y0Y1
lsl.l     #3,d0                 ; (4) Y=Y0XXY1XX
swap      d0                    ; (4) Y=Y1XXY0XX
add.w     d0,&old                ; (2) old=old+Y0
lsr.w     #1,&old                ; (4) old=(old+Y0)/2
move.b    &UV,&old              ; (2) old=YI0UV
andi.w    #53FFF,&old           ; (4) old=0YUV(I0)
move.l     (&IND,&old.w*4),d1    ; (2+) d1=X1X3
move.w     d0,&old              ; (2) old=Y0
move.b     &UV,d0               ; (2) Y=Y0UV
andi.w    #53FFF,d0            ; (4) Y=0YUV(0)
move.l     (&IND,d0.w*4),d2    ; (2+) d2=0X2X
move.w     d1,d3               ; (2) exg.w d1,d2
move.w     d2,d1               ; (2) d1=X12X
move.w     d3,d2               ; (2) d2=0XX3
swap      d2                   ; (4) d2=X30X
lsl.l     #8,d1                ; (4) d1=12XX
lsl.l     #8,d2                ; (4) d2=30XX
swap      d0                   ; (4) Y=Y1XX
add.w     d0,&old              ; (2) old=old+Y1
lsr.w     #1,&old              ; (4) old=(old+Y1)/2
move.b    &UV,&old              ; (2) old=YI1UV
andi.w    #53FFF,&old          ; (4) old=0YUV(I1)
move.l     (&IND,&old.w*4),d3    ; (2+) d3=X1X3
move.w     d0,&old              ; (2) old=Y1
move.b     &UV,d0               ; (2) Y=Y0UV
andi.w    #53FFF,d0            ; (4) Y=0YUV(0)
move.l     (&IND,d0.w*4),d0     ; (2+) d0=0X2X
move.w     d0,d1               ; (2) exg.w d0,d3
move.w     d3,d0               ; (2) d0=0XX3
move.w     d1,d3               ; (2) d3=X12X
swap      d0                   ; (4) d0=X30X
lsr.l     #8,d0                ; (4) d0=X30
lsr.l     #8,d3                ; (4) d3=X12X
move.w     d0,d2               ; (2) d2=3030 (YiY0YiY1) (1)
move.w     d3,d1               ; (2) d1=2121 (YiY0YiY1) (2)

endm

macro
Y8x2a      &AY,&IND,&UV

GETY       &AY,&IND,&UV,d1,d2
move.l     &AY,d2                ; (2+) Y=Y0Y1
lsl.l     #3,d2                 ; (4) Y=Y0XXY1XX
move.b    &UV,d2                ; (2) Y=Y1UV
andi.w    #53FFF,d2            ; (4) Y=0YUV(Y1)
move.l     (&IND,d2.w*4),d1    ; (2+) d1=0123 (Y1)
swap      d2                   ; (4) Y=Y0XX
move.b    &UV,d2                ; (2) Y=Y0UV
andi.w    #53FFF,d2            ; (4) Y=0YUV(Y0)
move.l     (&IND,d2.w*4),d2    ; (2+) d2=0123 (Y0)
move.w     d1,d0               ; (2) exg.w d2,d1
move.w     d2,d1               ; (2) d1=0123 (Y1Y0)
move.w     d0,d2               ; (2) d2=0123 (Y0Y1)
swap      d1                   ; (4) d1=2301 (Y0Y1)

endm

macro
Y8x2b      &AY,&IND,&UV

GETY       &AY,&IND,&UV,d1,d2

```

- 745 -

Engineering:KlicsCode:CompPict:Colour.a

```

*      move.l    &AY,d2                ; (2+) Y=Y0Y1
*      lsl.l     #3,d2                  ; (4) Y=Y0XXY1XX
*      move.b    &UV,d2                  ; (2) Y=Y1UV
*      andi.w     #$3FFF,d2              ; (4) Y=0YUV(Y1)
*      move.l     (&IND,d2.w*4),d1       ; (2+) d1=0123 (Y1)
*      swap      d2                      ; (4) Y=Y0XX
*      move.b    &UV,d2                  ; (2) Y=Y0UV
*      andi.w     #$3FFF,d2              ; (4) Y=0YUV(Y0)
*      move.l     (&IND,d2.w*4),d2       ; (2+) d2=0123 (Y0)
*      ror.l     #8,d2                   ; (6) d2=3012 (Y0)
*      ror.l     #8,d1                   ; (6) d1=3012 (Y1)
*      move.w     d1,d0                  ; (2) exg.w d2,d1
*      move.w     d2,d1                  ; (2) d1=3012 (Y1Y0)
*      move.w     d0,d2                  ; (2) d2=3012 (Y0Y1)
*      swap      d1                      ; (4) d1=1230 (Y0Y1)
*      ror.w     #8,d1                   ; (6) d1=1203 (Y0Y1)
*
*      endm

```

OUT8x2 FUNC EXPORT

```

*
PS      RECORD      8
table   DS.L         1
pixmap  DS.L         1
Y        DS.L         1
U        DS.L         1
V        DS.L         1
width    DS.L         1
height   DS.L         1
rowByte  DS.L         1
pixmap2  DS.L         1
*      ENDR
*
LS      RECORD      0,DECR
Y1      DS.L         1
U_ex    DS.L         1
U_ey    DS.L         1
U_ix    DS.L         1
Y_y     DS.L         1
P_y     DS.L         1
LSize   EQU          *
*      ENDR

```

```

a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - old0, d7

```

```

link      a6,#LS.LSize
movem.l    d4-d7/a3-a5,-(a7)

```

```

*      move.l    PS.Y(a6),a0            ; Y=Yc
*      move.l    PS.U(a6),a1            ; U=Uc
*      move.l    PS.V(a6),a2            ; V=Vc
*      move.l    PS.pixmap(a6),a3       ; pm=pixmap
*      move.l    PS.table(a6),a4        ; tab=table
*      adda.l     #$00020000,a4          ; tab+=32768 (longs)
*      move.l    PS.pixmap2(a6),a5      ; pm2=pixmap2

```

```

*      move.l    PS.width(a6),d0        ; LOAD width
*      move.l    d0,LS.U_ix(a6)         ; SAVE U_ix
*      move.l    PS.height(a6),d1       ; LOAD height
*      mulu.w     d0,d1                  ; width*height
*      lsr.l     #1,d1                   ; width*height/2

```

- 746 -

Engineering:KlicsCode:CompPict:Colour.a

```

add.l    a1,d1                ; U+width*height/2
move.l   d1,LS.U_ey(a6)       ; SAVE U_ey
add.l    d0,d0                ; width*2
move.l   d0,LS.Y1(a6)         ; SAVE Y1
move.l   d0,LS.Y_y(a6)        ; SAVE Y_y
move.l   PS.rowByte(a6),d1    ; LOAD rowBytes
add.l    d1,d1                ; rowBytes*2
add.l    d1,d1                ; rowBytes*4
sub.l    d0,d1                ; rowBytes*4-width*2
move.l   d1,LS.P_y(a6)        ; SAVE P_y

move.l   PS.rowByte(a6),d5    ; load rowBytes
clr.l    d6
clr.l    d7

@do_y    move.l   LS.U_ix(a6),d0    ; LOAD U_ixB
add.l    a1,d0                ; P+U_ixB
move.l   d0,LS.U_ex(a6)        ; SAVE U_exB

@do_x    GETUV    a1,a2,d0,d4        ; d4=00UV00UV (10)

Y8x2a    (a0),a4,d4;;d6        ; calc d2,d1 pixels
move.l   d2,(a3)
add.l    d5,a3
move.l   d1,(a3)
add.l    d5,a3

move.l   LS.Y1(a6),d0          ; load Yrow
Y8x2b    (a0,d0.w),a4,d4;;d7    ; calc d2,d1 pixels
move.l   d2,(a3)
add.l    d5,a3
move.l   d1,(a3)+

swap     d4                    ; next UV
addq.l   #4,a0                 ; next Ys

move.l   LS.Y1(a6),d0          ; load Yrow
Y8x2b    (a0,d0.w),a4,d4;;d7    ; calc d2,d1 pixels
move.l   d1,(a3)
sub.l    d5,a3
move.l   d2,(a3)
sub.l    d5,a3

Y8x2a    (a0)+,a4,d4;;d6
move.l   d1,(a3)
sub.l    d5,a3
move.l   d2,(a3)+

cmpa.l   LS.U_ex(a6),a1
blt.w    @do_x

add.l    LS.Y_y(a6),a0
add.l    LS.P_y(a6),a3

cmpa.l   LS.U_ey(a6),a1
blt.w    @do_y

movem.l  (a7)+,d4-d7/a3-a5      ; restore registers
unlk     a6                    ; remove locals
rts      ; return

```

ENDFUNC

- 747 -

Engineering:KlicsCode:CompPict:Colour.a

```

macro
RGB2Y      &RGB,&Y,&U,&V,&AY

move.l     &RGB,d2                ; pixel=*pixmap
eorl.l     #$808080,d2            ; pixel^=0x808080
clr.w      d1                     ; B=0
move.b     d2,d1                  ; B=pixel[3]
move.l     4(a4,d1.w*8),d0        ; d0=by,bu
sub.w      d0,&U                  ; U=-bu
swap       d0                     ; d0=bu,by
move.w     d0,&Y                  ; Y=by
ext.w      d1                     ; (short)B
add.w      d1,d1                  ; B*=2
add.w      d1,&V                  ; V+=B<<1
lsr.l      #8,d2                  ; pixel>>=8
clr.w      d1                     ; G=0
move.b     d2,d1                  ; G=pixel[3]
move.l     4(a4,d1.w*8),d0        ; d0=gry,gv
sub.w      d0,&U                  ; U=-gv
swap       d0                     ; d0=gv,gry
sub.w      d0,&Y                  ; Y=-gry
move.l     4(a4,d1.w*8),d0        ; d0=gby,gu
sub.w      d0,&V                  ; V=-gv
swap       d0                     ; d0=gu,gby
sub.w      d0,&Y                  ; Y=-gby
ext.w      d1                     ; (short)G
sub.w      d1,&U                  ; U=-g
sub.w      d1,&V                  ; V=-g
lsr.l      #2,d1                  ; G<<=2
add.w      d1,&Y                  ; Y+=B<<1
lsr.l      #8,d2                  ; pixel>>=8
move.l     4(a4,d2.w*8),d0        ; d0=ry,rv
sub.w      d0,&V                  ; V=-rv
swap       d0                     ; d0=rv,ry
add.w      d0,&Y                  ; Y+=ry
ext.w      d2                     ; (short)R
add.w      d2,d2                  ; R*=2
add.w      d2,&U                  ; U+=R<<2
cmpi.w     #$FE40,&Y              ; Y>=-448
bge.s      @ok                   ; if greater
move.w     #$FE40,&Y              ; Y= -448
bra.s      @end                   ; save
@ok        cmpi.w     #$01C0,&Y    ; Y< 448
blt.s      @end                   ; if less
@end       move.w     #$01C0,&Y    ; Y= 443
           move.w     &Y,&AY      ; Save Y

endm

IN32      FUNC      EXPORT
*
PS        RECORD      8
table     DS.L        1
pixmap    DS.L        1
Y         DS.L        1
U         DS.L        1
V         DS.L        1
width     DS.L        1
height    DS.L        1
rowByte    DS.L        1
          ENDR
*
LS        RECORD      0,DECR

```

- 748 -

Engineering:KlicsCode:CompPict:Colour.a

```

Y1      DS.L      1      ; sizeof(short)*Yrow      = 2*width
U_ex    DS.L      1      ; x end address          = U+U_ix
U_ey    DS.L      1      ; y end address          = U+width*height>>
U_ix    DS.L      1      ; sizeof(short)*UVrow      = width
Y_y     DS.L      1      ; sizeof(short)*Yrow      = 2*width
P_y     DS.L      1      ; 2*rowBytes-sizeof(long)*Prow = 2*rowBytes-width
LSize   EQU       *
        ENDR

*
*      a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
*      d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - old0, d7
*
        link      a6,#LS.LSize      ; inc, width, fend and rowend are loca
        movem.l   d4-d7/a3-a5,-(a7) ; store registers

        move.l    PS.Y(a6),a0      ; Y=Yc
        move.l    PS.U(a6),a1      ; U=Uc
        move.l    PS.V(a6),a2      ; V=Vc
        move.l    PS.pixmap(a6),a3 ; pm=pixmap
        move.l    PS.table(a6),a4  ; tab=table

        move.l    PS.width(a6),d0   ; LOAD width
        move.l    d0,LS.U_ix(a6)    ; SAVE U_ix
        move.l    PS.height(a6),d1  ; LOAD height
        mulu.w    d0,d1             ; width*height
        lsr.l     #1,d1             ; width*height/2
        add.l     a1,d1             ; U+width*height/2
        move.l    d1,LS.U_ey(a6)    ; SAVE U_ey
        add.l     d0,d0             ; width*2
        move.l    d0,LS.Y1(a6)      ; SAVE Y1
        move.l    d0,LS.Y_y(a6)     ; SAVE Y_y
        add.l     d0,d0             ; width*4
        move.l    PS.rowByte(a6),d1 ; LOAD rowBytes
        add.l     d1,d1             ; rowBytes*2
        sub.l     d0,d1             ; rowBytes*2-width*4
        move.l    d1,LS.P_y(a6)     ; SAVE P_y

        move.l    PS.rowByte(a6),d7 ; load rowBytes
        move.l    LS.Y1(a6),d6      ; load Y1

@do_y   move.l    LS.U_ix(a6),d0     ; LOAD U_ixB
        add.l     a1,d0             ; P+U_ixB
        move.l    d0,LS.U_ex(a6)    ; SAVE U_exB

@do_x   clr.w     d4                 ; U=0
        clr.w     d5                 ; V=0

        RGB2Y     (a3,d7.w),d3,d4,d5,(a0,d6.w); Convert pixel
        RGB2Y     (a3)+,d3,d4,d5,(a0)+    ; Convert pixel
        RGB2Y     (a3,d7.w),d3,d4,d5,(a0,d6.w); Convert pixel
        RGB2Y     (a3)+,d3,d4,d5,(a0)+    ; Convert pixel

        asr.w     #2,d4             ; U>=>=2
        asr.w     #2,d5             ; V>=>=2

        cmpi.w    #SFE40,d4         ; U>=-448
        @okU      @okU              ; if greater
        move.w    #SFE40,d4         ; U= -448
        bra.s     @doV              ; save
        cmpi.w    #S01C0,d4         ; U< 448
        @okU      @doV              ; if less
        move.w    #S01C0,d4         ; U= 448

```

- 749 -

Engineering:KlicsCode:CompPict:Colour.a

```

@doV    cmpi.w    #$FE40,d5          ; V>=-448
        bge.s    @okV              ; if greater
        move.w    #$FE40,d5        ; V= -448
        bra.s     @end             ; save
@okV     cmpi.w    #$01C0,d5        ; V< 448
        blt.s     @end             ; if less
        move.w    #$01C0,d5        ; V= 448

@end     move.w    d4,(a1)+          ; Save U
        move.w    d5,(a2)+          ; Save V

        cmpa.l    LS.U_ex(a6),a1
        blt.w     @do_x

        add.l     LS.Y_y(a6),a0
        add.l     LS.P_y(a6),a3

        cmpa.l    LS.U_ey(a6),a1
        blt.w     @do_y

*
        movem.l   (a7)+,d4-d7/a3-a5 ; restore registers
        unlk      a6                ; remove locals
        rts       ; return

*
        ENDFUNC
        -----
        macro
        UV16      &AU, &AV, &SP, &UV

        move.l    (&AU)+,&SP
        move.l    (&AV)+,&UV
        UVOVER    &SP,&UV
        lsr.l     #5,&UV
        andi.l    #$03e003e0,&SP
        andi.l    #$001f001f,&UV
        or.l      &SP,&UV            ; UV==000UV00UV
        swap      &UV

        endm

        macro
        Y16x2     &AY,&IND,&UV

        move.l    &AY,d2
        lsl.l     #5,d2              ; (2+) Y=Y0Y1
        andi.l    #$FC00FC00,d2      ; (4) Y=Y0XXY1XX
        or.w      &UV,d2              ;
        move.l    (&IND,d2.w*4),d1    ; (2) Y=Y1UV
        swap      d2                 ; (2+) d1=0123 (Y1)
        or.w      &UV,d2              ; (4) Y=Y0XX
        move.l    (&IND,d2.w*4),d2    ; (2) Y=Y0UV
        ; (2+) d2=0123 (Y0)

        endm

OUT16x2 FUNC      EXPORT
*
PS          RECORD      8
table       DS.L        1
pixmap      DS.L        1
Y           DS.L        1
U           DS.L        1
V           DS.L        1

```



- 750 -

Engineering:KlicsCode:CompPict:Colour.a

```

width DS.L      1
height DS.L     1
rowByte DS.L    1
pixmap2 DS.L    1
        ENDR
*
LS      RECORD      0,DECR
Y1      DS.L      1          ; sizeof(short)*Yrow      = 2*width
U_ex    DS.L      1          ; x end address      = U+U_ix
U_ey    DS.L      1          ; y end address      = U+width*height>>
U_ix    DS.L      1          ; sizeof(short)*UVrow = width
Y_y     DS.L      1          ; sizeof(short)*Yrow  = 2*width
P_y     DS.L      1          ; 4*rowBytes-sizeof(long)*Prow = 4*rowBytes-width
LSize   EQU      *
        ENDR
*
*      a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
*      d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - old0, d7
*
link     a6,#LS.LSize      ; inc. width, fend and rowend are loca
movem.l  d4-d7/a3-a5,-(a7) ; store registers

move.l   PS.Y(a6),a0        ; Y=Yc
move.l   PS.U(a6),a1        ; U=Uc
move.l   PS.V(a6),a2        ; V=Vc
move.l   PS.pixmap(a6),a3   ; pm=pixmap
move.l   PS.table(a6),a4    ; tab=table
adda.l   #$00020000,a4      ; tab+=32768 (longs)
move.l   PS.pixmap2(a6),a5  ; pm2=pixmap2

move.l   PS.width(a6),d0    ; LOAD width
move.l   d0,LS.U_ix(a6)     ; SAVE U_ix
move.l   PS.height(a6),d1   ; LOAD height
mulu.w   d0,d1              ; width*height
lsr.l    #1,d1              ; width*height/2
add.l    a1,d1              ; U+width*height/2
move.l   d1,LS.U_ey(a6)     ; SAVE U_ey
add.l    d0,d0              ; width*2
move.l   d0,LS.Y1(a6)       ; SAVE Y1
move.l   d0,LS.Y_y(a6)      ; SAVE Y_y
add.l    d0,d0              ; width*4
move.l   PS.rowByte(a6),d1  ; LOAD rowBytes
add.l    d1,d1              ; rowBytes*2
add.l    d1,d1              ; rowBytes*4
sub.l    d0,d1              ; rowBytes*4-width*4
move.l   d1,LS.P_y(a6)      ; SAVE P_y

move.l   PS.rowByte(a6),d5   ; load rowBytes
clr.l    d6
clr.l    d7

@do_y    move.l   LS.U_ix(a6),d0      ; LOAD U_ixB
        add.l    a1,d0              ; P+U_ixB
        move.l   d0,LS.U_ex(a6)     ; SAVE U_exB

@do_x    GETUV      a1,a2,d0,d4      ; d4=00UV00UV (10)

        GETY      (a0),a4,d4,d1,d2  ; calc d2,d1 pixel
        move.l   d2,(a3)+
        move.l   d1,(a3)
        add.l    d5,a3
        swap     d1
        move.l   d1,(a3)

```

- 751 -

Engineering:KlicsCode:CompPict:Colour.a

```

swap      d2
move.l    d2,-(a3)
add.l     d5,a3

move.l    LS.Y1(a6),d0
GETY      (a0,d0.w),a4,d4,d1,d2 ; load Yrow
move.l    d2,(a3)+
move.l    d1,(a3)
add.l     d5,a3
swap      d1
move.l    d1,(a3)
swap      d2
move.l    d2,-(a3)

swap      d4
addq.l    #4,a0
add.l     #12,a3 ; next UV
; next Ys

move.l    LS.Y1(a6),d0
GETY      (a0,d0.w),a4,d4,d1,d2 ; load Yrow
move.l    d1,(a3)
move.l    d2,-(a3)
sub.l     d5,a3
swap      d2
move.l    d2,(a3)+
swap      d1
move.l    d1,(a3)
sub.l     d5,a3

GETY      (a0)+,a4,d4,d1,d2
move.l    d1,(a3)
move.l    d2,-(a3)
swap      d2
sub.l     d5,a3
move.l    d2,(a3)+
swap      d1
move.l    d1,(a3)+

cmpa.l    LS.U_ex(a6),a1
blt.w     @do_x

add.l     LS.Y_y(a6),a0
add.l     LS.P_y(a6),a3

cmpa.l    LS.U_ey(a6),a1
blt.w     @do_y

movem.l   (a7)+,d4-d7/a3-a5 ; restore registers
unlk      a6 ; remove locals
rts       ; return

```

ENDFUNC

```

-----
macro
Y16      &AY,&IND,&UV

move.l    &AY,d2 ; (2+) Y=Y0Y1
lsl.l     #5,d2 ; (4) Y=Y0XXY1XX
andi.l    #SFC00FC00,d2 ;
or.w      &UV,d2 ; (2) Y=Y1UV
move.l    (&IND,d2.w*4),d1 ; (2+) d1=Y1
swap      d2 ; (4) Y=Y0XX
or.w      &UV,d2 ; (2) Y=Y0UV

```

1

1

1

- 753 -

Engineering:KlicsCode:CompPict:Colour.a

Page 22

```

      add.l      a1,d0                ; P+U_ixB
      move.l     d0,LS.U_ex(a6)      ; SAVE U_exB
@do_x  GETUV      a1,a2,d0,d4        ; d4=00UV00UV (10)
      GETY      (a0),a4,d4,d1,d2    ; calc d2,d1 pixel
      move.w     d1,d2
      move.l     d2,(a3)
      add.l      d5,a3

      move.l     LS.Y1(a6),d0        ; load Yrow
      GETY      (a0,d0.w),a4,d4,d1,d2 ; calc d2,d1 pixels
      move.w     d1,d2
      move.l     d2,(a3)+

      swap      d4                  ; next UV
      addq.l     #4,a0              ; next Ys

      move.l     LS.Y1(a6),d0        ; load Yrow
      GETY      (a0,d0.w),a4,d4,d1,d2 ; calc d2,d1 pixels
      move.w     d1,d2
      move.l     d2,(a3)
      sub.l      d5,a3

      GETY      (a0)+,a4,d4,d1,d2
      move.w     d1,d2
      move.l     d2,(a3)+

      cmpa.l     LS.U_ex(a6),a1
      blt.w      @do_x

      add.l      LS.Y_y(a6),a0
      add.l      LS.P_y(a6),a3

      cmpa.l     LS.U_ey(a6),a1
      blt.w      @do_y
*
      movem.l    (a7)+,d4-d7/a3-a5   ; restore registers
      unlk      a6                  ; remove locals
      rts                          ; return
      ENDFUNC
-----
      END

```

- 754 -

Engineering:KlicsCode:CompPict:Color2.a

```

-----
*
*   © Copyright 1993 KLICS Limited
*   All rights reserved.
*
*   Written by: Adrian Lewis
*
-----
*
*   68000 Fast RGB/YUV code
*
-----
*   include 'Traps.a'
*   machine mc68030
*
-----
*   macro
*   RGB2Y    &Apixel,&AY
*
*   d0 - pixel/r, d1 - g/2g+r, d2 - b, d3 - Y
*
*   move.l    &Apixel,d0      ; pixel=*Apixel
*   eor.l     #S00808080,d0    ; signed pixels
*
*   move.b    d0,d2           ; b=pixel[3]
*   ext.w     d2              ; b is 8(16) bit
*
*   move.w     d0,d1          ; g=pixel[2]
*   asr.w     #7,d1           ; 2g is 9(16) bit
*
*   swap      d0              ; r=pixel[1]
*   ext.w     d0              ; r is 8(16) bit
*
*   move.w     d2,d3          ; Y=b
*   lsl.w     #3,d3           ; Y<=3
*   sub.w     d2,d3          ; Y-=b
*
*   add.w     d0,d1           ; 2g+=r
*   add.w     d1,d3           ; Y+=2g+r
*   add.w     d1,d3           ; Y+=2g+r
*   add.w     d1,d3           ; Y+=2g+r
*   asr.w     #4,d3           ; Y>=4
*   add.w     d1,d3           ; Y+=2g+r
*   move.w     d3,&AY         ; AY=Y is 10(16) bit
*
*   endm
*
-----
*   macro
*   RGB2UV    &AU,&AV
*
*   d0 - r, d2 - b, d3 - Y, d1 - U/V
*
*   add.w     d0,d0           ; r is 9(16) bit
*   add.w     d2,d2           ; b is 9(16) bit
*   asr.w     #1,d3           ; Y is 9(16) bit
*   move.w     d2,d1          ; U=b
*   sub.w     d3,d1           ; U=b-Y
*   move.w     d1,&AU         ; AU=U
*   move.w     d0,d1          ; V=r
*   sub.w     d3,d1           ; V=r-Y
*   move.w     d1,&AV         ; AV=V
*
*   endm
*
-----

```

- 755 -

Engineering:KlicsCode:CompPict:Color2.a

```

if &TYPE('seg')!='UNDEFINED' then
seg      &seg
endif

RGB2YUV2      FUNC      EXPORT
*
      link      a6,#0      ; no local variables
      movem.l   d4-d7/a3,-(a7)      ; store registers
*
      move.l    $0008(a6),a3      ; pm=pixmap
      move.l    $000C(a6),a0      ; Y=Yc
      move.l    $0010(a6),a1      ; U=Uc
      move.l    $0014(a6),a2      ; V=Vc
      move.l    $0018(a6),d7      ; fend=area
      asl.l     #2,d7      ; fend<=2
      add.l     a3,d7      ; fend+=pm
      move.l    $001C(a6),d4      ; width_b=width
      asl.l     #2,d4      ; width_b<=2
      move.l    $0020(a6),d5      ; inc_b=cols
      asl.l     #2,d5      ; cols<=2
      sub.l     d4,d5      ; inc_b-=width_b
      @do1      move.l    a3,d6      ; rowend=pm
      add.l     d4,d6      ; rowend+=width_b
      @do2      rgb2y     (a3)+,(a0)+      ; rgb2y(pm++,Y++)
      rgb2uv    (a1)+,(a2)+      ; rgb2uv(U++,V++)
      rgb2y     (a3)+,(a0)+      ; rgb2y(pm++,Y++)
      cmpa.l    d6,a3      ; rowend>pm
      blt.s     @do2      ; while
      adda.l    d5,a3      ; pm+=inc_b
      move.l    a3,d6      ; rowend=pm
      add.l     d4,d6      ; rowend+=width_b
      @do3      rgb2y     (a3)+,(a0)+      ; rgb2y(pm++,Y++)
      cmpa.l    d6,a3      ; rowend>pm
      blt.s     @do3      ; while
      adda.l    d5,a3      ; pm+=inc_b
      cmpa.l    d7,a3      ; fend>pm
      blt.w     @do1      ; while --
*
      movem.l   (a7)+,d4-d7/a3      ; restore registers
      unlk      a6      ; remove locals-
      rts      ; return
*
      ENDFUNC
*-----
      macro
      FETCHY      &AY, &Y, &R, &G, &B
*
      move.l      &AY,&Y      ; Y=*AY++
      add.l       &Y,&R      ; RR+=Y12
      add.l       &Y,&G      ; GG+=Y12
      add.l       &Y,&B      ; BB+=Y12
*
      endm
*-----
      macro
      FIXOV      &V, &SP1, &SP2
*
      move.w      &V,&SP1
      clr.b       &SP1
      andi.w      #$3FFF,&SP1
      sne         &SP1
      btst        #13,&SP1
      seq         &SP2

```

- 756 -

Engineering:KlicsCode:CompPict:Color2.a

```

or.b      &SP1,&V
and.w     &SP2,&V
swap
move.w    &V,&SP1
clr.b     &SP1
andi.w    #03FFF,&SP1
sne       &SP1
btst      #13,&SP1
seq       &SP2
or.b      &SP1,&V
and.w     &SP2,&V
swap      &V
*
endm
-----
macro
OVERFLOW    &A, &B, &SP1, &SP2
*
*   move.l    #0FFF0000,&SP1           ; sp1=mask
*   move.l    &A,&SP2                 ; sp2=ovov (A)
*   and.l     &SP1,&SP2               ; sp2=0000 (A)
*   lsr.l     #8,&SP2                 ; sp2=0000 (A)
*   and.l     &B,&SP1                 ; sp1=0000 (B)
*   or.l      &SP2,&SP1               ; sp1=0000 (BABA)
*   move.l    &A,&SP1
*   or.l      &B,&SP1
*   andi.l    #0FFF0000,&SP1
*   beq.s     @ok                     ; if no overflow
*   clr.w     &SP2                     ; AND=0
*   FIXOV     &A,&SP1,&SP2             ; A1 overflow
*   FIXOV     &B,&SP1,&SP2             ; B1 overflow
@ok
*
endm
-----
macro
MKRGB       &R, &G, &B, &ARGB
*
*   lsl.l     #8,&G                     ; G=G0G0 (12)
*   or.l      &B,&G                     ; G=GBGB (12)
*   move.l    &R,&B                     ; B=0R0R (12)
*   swap      &B                       ; B=0R0R (21)
*   move.w    &G,&B                     ; B=0RGB (2)
*   swap      &G                       ; G=GBGB (21)
*   move.w    &G,&R                     ; R=0RGB (1)
*   move.l    &R,&ARGB                  ; *RGB++=rgb (1)
*   move.l    &B,&ARGB                  ; *RGB++=rgb (2)
*
endm
-----
macro
DUPVAL      &V0, &V1
*
*   move.w    &V0,&V1                   ; v1=v0
*   swap      &V0
*   move.w    &V1,&V0                   ; dup v0
*   move.l    &V0,&V1                   ; dup v1
*
endm
-----
macro
UV2RGB3     &AU,&AV
*

```

- 757 -

Engineering:KlicsCode:CompPict:Color2.a

```

*      d1 - ra, d2 - ga, d3 - ba, d4 - rb, d5 - gb/512, d6 - bb
*
      move.w    #512,d5          ; d5=512
      move.w    &AU,d2          ; U=*AU++
      add.w     d2,d2           ; U is 10(16) bits
      move.w    d2,d3          ; ba=U
      add.w     d3,d2           ; ga=2U
      add.w     d3,d2           ; ga=3U
      add.w     d5,d3           ; ba+=512
      DUPVAL    d3,d6          ; ba=bb=BB
      asr.w     #4,d2           ; ga=3U>>4
      move.w    &AV,d1         ; V=*AV++
      add.w     d1,d2           ; ga+=V
      add.w     d1,d1           ; ra*=2
      add.w     d5,d1           ; ra+=512
      DUPVAL    d1,d4          ; ra=rb=RR
      sub.w     d2,d5           ; gb=512-ga
      DUPVAL    d5,d2          ; ga=gb=GG
*
      endm
*-----*
      if &TYPE('seg')<='UNDEFINED' then
      seg      &seg
      endif
*
YUV2RGB2      FUNC      EXPORT
*
PS      RECORD      8
pixmap    DS.L      1
Y         DS.L      1
U         DS.L      1
V         DS.L      1
area      DS.L      1
width     DS.L      1
cols      DS.L      1
      ENDR
*
LS      RECORD      0,DECR
inc      DS.L      1
width    DS.L      1
fend     DS.L      1
count    DS.L      1
LSize    EQU      *
      ENDR
*
*      a0 - Y0, a1 - Y1, a2 - U, a3 - V, a4 - pm0, a5 - pm1
*      d0..6 - used, d7 - count
*
      link      a6,#LS.LSize
      movem.l   d4-d7/a3-a5,-(a7) ; inc, width, fend and rowend are loca
*                                     ; store registers
*
      move.l    PS.pixmap(a6),a4 ; pm0=pixmap
      move.l    a4,a5             ; pm1=pm0
      move.l    PS.Y(a6),a0       ; Y0=Yc
      move.l    a0,a1             ; Y1=Y0
      move.l    PS.U(a6),a2       ; U=Uc
      move.l    PS.V(a6),a3       ; V=Vc
      move.l    PS.area(a6),d7    ; fend=area
      lsl.l     #2,d7             ; fend<==2
      add.l     a4,d7             ; fend+=pm0
      move.l    d7,LS.fend(a6)    ; save fend
      move.l    PS.width(a6),d5   ; width=width
      move.l    d5,d7             ; count=width

```



- 758 -

Engineering:KlicsCode:CompPict:Color2.a

```

asr.l      #1,d7                ; count>>=1
subq.l     #1,d7                ; count-=1
move.l     d7,PS.width(a6)      ; save width
add.l      d5,d5                ; width*=2
add.l      d5,a1                ; Y1+=width
add.l      d5,d5                ; width*=2
move.l     d5,LS.width(a6)      ; save width
move.l     PS.cols(a6),d4       ; inc=cols
lsl.l      #2,d4                ; inc<=2
add.l      d4,a5                ; pml+=inc
add.l      d4,d4                ; cols*=2
sub.l      d5,d4                ; inc now 2*cols-width bytes
move.l     d4,LS.inc(a6)        ; save inc
@do
UV2RGB3    (a2)+,(a3)+          ; uv2rgb(*U++,*V++)
FETCHY     (a0)+,d0,d1,d2,d3    ; add Ya to RGB values
FETCHY     (a1)+,d0,d4,d5,d6    ; add Yb to RGB values
move.w     #3FFF,d0            ; d0=mask
lsl.l      #2,d1                ; d1 8(16) bits
and.w      d0,d1                ; d1 masked
lsl.l      #2,d2                ; d2 8(16) bits
and.w      d0,d2                ; d2 masked
lsl.l      #2,d3                ; d3 8(16) bits
and.w      d0,d3                ; d3 masked
lsl.l      #2,d4                ; d4 8(16) bits
and.w      d0,d4                ; d4 masked
lsl.l      #2,d5                ; d5 8(16) bits
and.w      d0,d5                ; d5 masked
lsl.l      #2,d6                ; d6 8(16) bits
and.w      d0,d6                ; d6 masked
move.l     d1,d0
or.l       d2,d0
or.l       d3,d0
or.l       d4,d0
or.l       d5,d0
or.l       d6,d0
andi.l     #FFF0FFF0,d0
bne.s      @over
@ok
MKRGB      d1,d2,d3,(a4)+        ; if overflow
MKRGB      d4,d5,d6,(a5)+        ; save RGBa
dbf        d7,@do               ; save RGBb
adda.l     LS.inc(a6),a4         ; while
adda.l     LS.inc(a6),a5         ; pm0+=inc
adda.l     LS.width(a6),a0       ; pm1+=inc
exg.l      a0,a1                ; Y0+=width
move.l     PS.width(a6),d7       ; Y1<=>Y0
cmpa.l     LS.fend(a6),a4        ; count=width
blt.w      @do                 ; pm0<fend
; while

movem.l     (a7)+,d4-d7/a3-a5    ; restore registers
unlk       a6                  ; remove locals
rts        ; return
@over
move.l     d7,LS.count(a6)       ; save count
clr.w      d7                  ; AND=0

FIXOV      d1,d0,d7             ; A overflow
FIXOV      d2,d0,d7             ; B overflow
FIXOV      d3,d0,d7             ; A overflow
FIXOV      d4,d0,d7             ; B overflow
FIXOV      d5,d0,d7             ; A overflow
FIXOV      d6,d0,d7             ; B overflow
move.l     LS.count(a6),d7       ; restore count
bra        @ok

```

- 759 -

Engineering:KlicsCode:CompPict:Color2.a

```

      ENDFUNC
      -----
      if &TYPE('seg')!='UNDEFINED' then
      seg      &seg
      endif

GREY2Y  FUNC      EXPORT
*
PS      RECORD      8
pixmap  DS.L        1
Y        DS.L        1
area     DS.L        1
width    DS.L        1
cols     DS.L        1
      ENDR

*
*   d0 - vvvv, d1 - v0v1, d2 - v2v3, d3 - xor, d4 - width, d5 - inc, d6 - rowend,
*   a0 - pm, a1 - Y
*
      link          a6,#0                      ; no local variables
      movem.l       d4-d7,-(a7)                ; store registers

      move.l        PS.pixmap(a6),a0           ; pm=pixmap
      move.l        PS.Y(a6),a1                ; Y=Yc
      move.l        PS.area(a6),d7             ; fend=area
      add.l         a0,d7                      ; fend+=pm
      move.l        PS.width(a6),d4            ; width_b=width
      move.l        PS.cols(a6),d5             ; inc_b=cols
      sub.l         d4,d5                      ; inc_b-=width_b
      move.l        #$7F7F7F7F,d3              ; xor=$7F7F7F7F
@dol1     move.l        a0,d6                  ; rowend=pm
      add.l         d4,d6                      ; rowend+=width_b
@dol2     move.l        (a0)+,d0               ; vvvv=*pm
      eor.l         d3,d0                     ; vvvv is signed
      move.w        d0,d2                      ; d2=v2v3
      asr.w         #6,d2                      ; d2=v2 (10 bits)
      swap          d2                        ; d2=v2??-
      move.b        d0,d2                     ; d2=v2v3
      ext.w         d2                        ; v3 extended
      lsl.w         #2,d2                     ; d2=v2v3 (10 bits)
      swap          d0                        ; d0=v0v1
      move.w        d0,d1                     ; d1=v0v1
      asr.w         #6,d1                     ; d1=v0 (10 bits)
      swap          d1                        ; d1=v0??
      move.b        d0,d1                     ; d1=v0v1
      ext.w         d1                        ; v1 extended
      lsl.w         #2,d1                     ; d1=v0v1 (10 bits)
      move.l        d1,(a1)+                  ; *Y=d1
      move.l        d2,(a1)+                  ; *Y=d2
      cmpa.l        d6,a0                     ; rowend>pm
      blt.s         @dol2                     ; while
      adda.l        d5,a0                     ; pm+=inc_b
      cmpa.l        d7,a0                     ; fend>pm
      blt.s         @dol1                     ; while

      movem.l       (a7)+,d4-d7               ; restore registers
      unlk          a6                        ; remove locals
      rts                               ; return

      ENDFUNC
      -----
      if &TYPE('seg')!='UNDEFINED' then
      seg      &seg

```

- 760 -

Engineering:KlicsCode:CompPict:Color2.a

```

endif
Y2GREY  FUNC      EXPORT
*
PS      RECORD      8
pixmap  DS.L        1
Y        DS.L        1
height  DS.L        1
width    DS.L        1
cols     DS.L        1
        ENDR
*
d0- spare, d1 - v43, d2 - v21, d3 - spare, d4 - width, d5 - inc, d6 - count, d
a0 - pm, a1 - Y
*
        link        a6,#0                ; no local variables
        movem.l     d4-d7,-(a7)          ; store registers
*
        move.l      PS.pixmap(a6),a0     ; pm=pixmap
        move.l      PS.Y(a6),a1         ; Y=Yc
        move.l      PS.height(a6),d7     ; long height
        subq.l      #1,d7               ; height--
        move.l      PS.width(a6),d4      ; long width
        move.l      PS.cols(a6),d5       ; long inc=cols
        sub.l       d4,d5               ; inc--width
        lsr.l       #2,d4               ; width>>=2 (read 4 values)
        subq.l      #1,d4               ; width--
@do1     move.l      d4,d6               ; count=width
@dc2     move.l      (a1)+,d0             ; d0=x4x3
        move.l      (a1)+,d1             ; d1=x2x1
        move.l      #01FF01FF,d2        ; d2=511
        move.l      d2,d3               ; d3=511
        sub.l       d0,d2               ; unsigned d2
        sub.l       d1,d3               ; unsigned d3
        lsr.l       #2,d2
        lsr.l       #2,d3
        move.l      d2,d0
        or.l        d3,d0
        andi.l      #03F003F00,d0
@ok      bne.s       @over               ; if no overflow
        lsl.w       #8,d3               ; d3=0210
        lsl.w       #8,d2               ; d2=0430
        lsr.l       #8,d3               ; d3=0021
        lsl.l       #8,d2               ; d2=4300
        or.l        d3,d2               ; d2=4321
        move.l      d2,(a0)+            ; *pm=d2
        dbf         d6,@do2             ; while -1!--count
        adda.l      d5,a0               ; pm+=inc_b
        dbf         d7,@do1             ; while -1!--height
*
        movem.l     (a7)+,d4-d7         ; restore registers
        unlk        a6                 ; remove locals
@over    rts                          ; return
        clr.w       d1                 ; AND=0
        FIXOV       d2,d0,d1           ; A overflow
        FIXOV       d3,d0,d1           ; B overflow
        bra.s       @ok
*
        ENDFUNC
*-----
macro
GGG      &V,&SP1,&SP2,&AV

```

- 761 -

Engineering:KlicsCode:CompPict:Color2.a

```

        move.l    &V,&SP2                ; SP2=0102
        lsl.l     #8,&SP2                ; SP2=1020
        or.l      &V,&SP2                ; SP2=1122
        move.l    &V,&SP1                ; SP1=0102
        swap      &SP1                  ; SP1=0201
        move.w    &SP2,&SP1              ; SP1=0222
        swap      &SP2                  ; SP2=2211
        move.w    &SP2,&V                ; V=0111
        move.l    &V,&AV                 ; *pm=V
        move.l    &SP1,&AV               ; *pm=SP1

    endm

    -----
    if &TYPE('seg')!='UNDEFINED' then
        seg      &seg
    endif

Y2GGG    FUNC      EXPORT
*
PS        RECORD      8
pixmap    DS.L        1
Y          DS.L        1
lines     DS.L        1
width     DS.L        1
cols      DS.L        1
        ENDR
*
*   d0 - v, d4 - width, d5 - inc, d6 - count, d7 - lines
*   a0 - pm, a1 - Y
*
        link      a6,#0                  ; no local variables
        movem.l   d4-d7,-(a7)            ; store registers
*
        move.l    PS.pixmap(a6),a0        ; pm=pixmap
        move.l    PS.Y(a6),a1             ; Y=Yc
        move.l    PS.lines(a6),d7         ; long lines
        subq.l    #1,d7                   ; lines-=1
        move.l    PS.width(a6),d4         ; long width
        move.l    PS.cols(a6),d5          ; inc=cols
        sub.l     d4,d5                   ; inc-=width
        lsl.l     #2,d5                   ; inc (bytes)
        lsr.l     #2,d4                   ; width>>=2
        subq.l    #1,d4                   ; width-=1
@dc1      move.l   d4,d6                   ; count=width
@dc2      move.l   (a1)+,d0                ; d0=x1x2 (10 bits signed)
        move.l    (a1)+,d1                ; d1=x3x4 (10 bits)
        move.l    #$02000200,d3           ; d3=plus
        add.l     d3,d0                   ; d0=x1x2 (unsigned)
        add.l     d3,d1                   ; d1=x3x4 (unsigned)
        lsr.l     #2,d0                   ; d0=x1x2 (10,8 bits)
        lsr.l     #2,d1                   ; d1=x3x4 (10,8 bits)
        move.w    #$3FFF,d2              ; d2=mask
        and.w     d2,d0                   ; mask d0
        and.w     d2,d1                   ; mask d1
        move.l    d0,d2
        or.l      d1,d2
        andi.l    #SFF00FF00,d2
        bne.s     @over                   ; if no overflow
@ok        GGG      d0,d2,d3,(a0)+        ; while -1!--count
        GGG      d1,d2,d3,(a0)+        ; pm+=inc_b
        dbf      d6,@dc2                ; while -1!--lines
        adda.l    d5,a0
        dbf      d7,@dc1

```

- 762 -

Engineering:KlicsCode:CompPict:Color2.a

```

movem.l    (a7)+,d4-d7      ; restore registers
unlk       a6               ; remove locals
rts        ; return
@over      clr.w            d3      ; AND=0
FIXOV      d0,d2,d3         ; A overflow
FIXOV      d1,d2,d3         ; B overflow
bra.w      @ok

```

ENDFUNC

```

-----
macro
MKRGB2      &R, &G, &B, &ARGB, &ROW, &XX

    lsl.l    #8,&G           ; G=G0G0 (12)
    or.l     &B,&G           ; G=GBGB (12)
    move.l   &R,&B           ; B=0R0R (12)
    swap     &B             ; B=0R0R (21)
    move.w   &G,&B           ; B=0RGB (2)
    swap     &G             ; G=GBGB (21)
    move.w   &G,&R           ; R=0RGB (1)

    andi.l   $FFFEFEFE,&R    ; 7 bits for interpolation
    andi.l   $FFFEFEFE,&B    ; 7 bits for interpolation

    move.l   &R,&G           ; G=RGB(1)
    add.l    &B,&G           ; G+=RGB(2)
    lsr.l    #1,&G           ; G/=2

    move.l   &B,&XX          ; XX=RGB(2)
    sub.l    &R,&XX          ; XX-=RGB(1)
    lsr.l    #1,&XX          ; XX/=2
    add.l    &B,&XX          ; XX+=B

    move.l   &R,(&ARGB)+     ; *RGB++=rgb (1)
    move.l   &G,(&ARGB)+     ; *RGB++=rgb (1.5)
    move.l   &B,(&ARGB)+     ; *RGB++=rgb (2)
    move.l   &B,(&ARGB)+     ; *RGB++=rgb (2.5)

    add.l    &ROW,&ARGB
    sub.l    #16,&ARGB

    move.l   &R,(&ARGB)+     ; *RGB++=rgb (1)
    move.l   &G,(&ARGB)+     ; *RGB++=rgb (1.5)
    move.l   &B,(&ARGB)+     ; *RGB++=rgb (2)
    move.l   &B,(&ARGB)+     ; *RGB++=rgb (2.5)

    sub.l    &ROW,&ARGB

```

endm

```

-----
if &TYPE('seg')# 'UNDEFINED' then
seg      &seg
endif

```

YUV2RGB3	FUNC	EXPORT
PS	RECORD	8
pixmap	DS.L	1
Y	DS.L	1
U	DS.L	1
V	DS.L	1
area	DS.L	1

- 763 -

Engineering:KlicsCode:CompPict:Color2.a

```

width    DS.L      1
cols     DS.L      1
        ENDR

*
LS        RECORD    0,DECR
inc       DS.L      1
width     DS.L      1
fend      DS.L      1
count     DS.L      1
row       DS.L      1
LSize     EQU       *
        ENDR

*
*      a0 - Y0, a1 - Y1, a2 - U, a3 - V, a4 - pm0, a5 - pm1
*      d0..6 - used, d7 - count
*
        link        a6,#LS.LSize          ; inc, width, fend and rowend are loca
movem.l   d4-d7/a3-a5,-(a7)              ; store registers

        move.l      PS.pixmap(a6),a4      ; pm0=pixmap
        move.l      a4,a5                 ; pm1=pm0
        move.l      PS.Y(a6),a0           ; Y0=Yc
        move.l      a0,a1                 ; Y1=Y0
        move.l      PS.U(a6),a2           ; U=Uc
        move.l      PS.V(a6),a3           ; V=Vc
        move.l      PS.area(a6),d7        ; fend=area
        lsl.l       #2,d7                 ; fend<=2
        add.l       a4,d7                 ; fend+=pm0
        move.l      d7,LS.fend(a6)         ; save fend
        move.l      PS.width(a6),d5       ; width=width
        move.l      d5,d7                 ; count=width
        asr.l       #1,d7                 ; count>=1
        subq.l      #1,d7                 ; count-=1
        move.l      d7,PS.width(a6)       ; save width
        add.l       d5,d5                 ; width*=2
        add.l       d5,a1                 ; Y1+=width
        add.l       d5,d5                 ; width*=2
        move.l      d5,LS.width(a6)       ; save width
        move.l      PS.cols(a6),d4        ; inc=cols
        lsl.l       #2,d4                 ; inc<=2
        move.l      d4,LS.row(a6)         ; *NEW save row
        add.l       d4,a5                 ; pm1+=inc
        add.l       d4,a5                 ; *NEW pm1+=inc
        add.l       d4,d4                 ; cols*=2
        add.l       d4,d4                 ; *NEW cols*=2
        sub.l       d5,d4                 ; inc now 4*cols-width bytes
        sub.l       d5,d4                 ; *NEW inc now 4*cols-width bytes (wid
        move.l      d4,LS.inc(a6)         ; save inc
@do       UV2RGB3      (a2)+,(a3)+        ; uv2rgb(*U++,*V++)

        FETCHY      (a0)+,d0,d1,d2,d3    ; add Ya to RGB values
        FETCHY      (a1)+,d0,d4,d5,d6    ; add Yb to RGB values

        move.w       #$3FFF,d0           ; d0=mask
        lsr.l       #2,d1                 ; d1 8(16) bits
        and.w        d0,d1                 ; d1 masked
        lsr.l       #2,d2                 ; d2 8(16) bits
        and.w        d0,d2                 ; d2 masked
        lsr.l       #2,d3                 ; d3 8(16) bits
        and.w        d0,d3                 ; d3 masked
        lsr.l       #2,d4                 ; d4 8(16) bits
        and.w        d0,d4                 ; d4 masked
        lsr.l       #2,d5                 ; d5 8(16) bits

```

- 764 -

Engineering:KlicsCode:CompPict:Color3.a

```

and.w    d0,d5                ; d5 masked
lsr.l    #2,d5                ; d5 8(16) bits
and.w    d0,d5                ; d6 masked

move.l    d1,d0
or.l     d2,d0
or.l     d3,d0
or.l     d4,d0
or.l     d5,d0
or.l     d6,d0
andi.l    #FFF00FF0,d0
bne.w    @over                ; if overflow

@ok      MKRGB2    d1,d2,d3,a4,LS.row(a6),d0    ; *NEW save RGBa
MKRGB2    d4,d5,d6,a5,LS.row(a6),d0    ; *NEW save RGBb
dbf       d7,@do                ; while
adda.l    LS.inc(a6),a4          ; pm0+=inc
adda.l    LS.inc(a6),a5          ; pm1+=inc
adda.l    LS.width(a6),a0        ; Y0+=width
exg.l     a0,a1                  ; Y1<->Y0
move.l    PS.width(a6),d7        ; count=width
cmpa.l    LS.fend(a6),a4         ; pm0<fend
blt.w     @do                    ; while

movem.l    (a7)+,d4-d7/a3-a5      ; restore registers
unlk       a6                    ; remove locals
rts        ; return

@over     move.l    d7,LS.count(a6) ; save count
clr.w     d7                    ; AND=0
FIXOV     d1,d0,d7              ; A overflow
FIXOV     d2,d0,d7              ; B overflow
FIXOV     d3,d0,d7              ; A overflow
FIXOV     d4,d0,d7              ; B overflow
FIXOV     d5,d0,d7              ; A overflow
FIXOV     d6,d0,d7              ; B overflow
move.l    LS.count(a6),d7        ; restore count
bra       @ok

ENDFUNC
-----
macro
FETCHY2    &AY, &Y, &R, &G, &B

move.l     &AY,&Y                ; Y
asr.w     #2,&Y
swap      &Y
asr.w     #2,&Y
swap      &Y                    ; Y is -128 to +127
add.l     &Y,&R                  ; RED, Get (Y+ 2V + 512) for Red = (Y +
add.l     &Y,&G                  ; GREEN, Get (Y + (512 - (6U/16)) - V)
add.l     &Y,&B                  ; BLUE, Get (Y + (2U + 512) for Blue = (

endm
-----
macro
UV2RGB4    &AU,&AV

move.w     &AU,d2                ; U
and.w     #503FF,d2
move.l     (a6,d2.w*8),d3          ; BLUE, Get (2U + 512)/4 for Blue = (Y +
move.l     d3,d6                  ; Dup for second pair
move.l     4(a6,d2.w*8),d5        ; GREEN, Get (512 - (6U/16))/4 for Gree
move.w     &AV,d1                ; V

```

- 765 -

Engineering:KlicsCode:CompPict:Color2.a

```

        move.w    d1,d4
        asr.w     #2,d1
        sub.w     d1,d5                ;GREEN, Get (512 - (6U/16) - V)/4 for
        move.w    d5,d2
        swap      d5
        move.w    d2,d5
        move.l     d5,d2                ;Dup for second pair

        and.w     #503FF,d4
        move.l     (a6,d4.w*8),d4       ;RED, Get (2V + 512)/4 for Red = (Y +
        move.l     d4,d1

        endm
-----
MKRGB2SUB  FUNC      EXPORT
        MKRGB2     d1,d2,d3,a4,d7,d0    ;*NEW save RGBa
        MKRGB2     d4,d5,d6,a5,d7,d0    ;*NEW save RGBb
        rts

        ENDFUNC

OVERSUB  FUNC      EXPORT
        move.l     d1,d0
        or.l       d2,d0
        or.l       d3,d0
        or.l       d4,d0
        or.l       d5,d0
        or.l       d6,d0
        andi.l     #$FFF0FF00,d0
        bne.s      @over                ; if overflow
@ok       rts
@over     move.l     d7,-(sp)              ; save count
        clr.w     d7                    ; AND=0
        FIXOV     d1,d0,d7              ; A overflow
        FIXOV     d2,d0,d7              ; B overflow
        FIXOV     d3,d0,d7              ; A overflow
        FIXOV     d4,d0,d7              ; B overflow
        FIXOV     d5,d0,d7              ; A overflow
        FIXOV     d6,d0,d7              ; B overflow
        move.l     (sp)+,d7              ; restore count
        bra       @ok

        ENDFUNC

UV2RGB4SUB  FUNC      EXPORT
        UV2RGB4     (a2)+,(a3)+          ; uv2rgb(*U++,*V++)
        rts

        ENDFUNC

FETCHY2SUB  FUNC      EXPORT
        FETCHY2     (a0)+,d0,d1,d2,d3    ; add Ya to RGB values
        FETCHY2     (a1)+,d0,d4,d5,d6    ; add Yb to RGB values
        rts

        ENDFUNC

        if &TYPE('seg')≠'UNDEFINED' then

```



- 766 -

Engineering:KlicsCode:CompPict:Color2.a

```

        seg      &seg
    endif

YUV2RGB5    FUNC    EXPORT
*
PS          RECORD    3
Table       DS.L      1
pixmap     DS.L      1
Y          DS.L      1
U          DS.L      1
V          DS.L      1
area       DS.L      1
width      DS.L      1
cols       DS.L      1
          ENDR
*
LS          RECORD    0,DECR
inc         DS.L      1
width      DS.L      1
fend       DS.L      1
count      DS.L      1
row        DS.L      1
LSize      EQU        *
          ENDR
*
a0 - Y0, a1 - Y1, a2 - U, a3 - V, a4 - pm0, a5 - pm1
d0..6 - used, d7 - count

link        a6,#LS.LSize          ; inc, width, fend and rowend are loca
movem.l     d4-d7/a3-a5,-(a7)      ; store registers

move.l      PS.pixmap(a6),a4       ; pm0=pixmap
move.l      a4,a5                  ; pm1=pm0
move.l      PS.Y(a6),a0            ; Y0=Yc
move.l      a0,a1                  ; Y1=Y0
move.l      PS.U(a6),a2            ; U=Uc
move.l      PS.V(a6),a3            ; V=Vc
move.l      PS.area(a6),d7         ; fend=area
lsl.l       #2,d7                  ; fend<=2
add.l       a4,d7                  ; fend+=pm0
move.l      d7,LS.fend(a6)         ; save fend
move.l      PS.width(a6),d5        ; width=width
move.l      d5,d7                  ; count=width
asr.l       #1,d7                  ; count>=1
subq.l      #1,d7                  ; count-=1
move.l      d7,PS.width(a6)        ; save width

add.l       d5,d5                  ; width*=2
add.l       d5,a1                  ; Y1+=width
add.l       d5,d5                  ; width*=2
move.l      d5,LS.width(a6)        ; save width
move.l      PS.cols(a6),d4         ; inc=cols
lsl.l       #2,d4                  ; inc<=2
move.l      d4,LS.row(a6)          ; *NEW save row
add.l       d4,a5                  ; pm1+=inc
add.l       d4,a5                  ; *NEW pm1+=inc
add.l       d4,d4                  ; cols*=2
add.l       d4,d4                  ; *NEW cols*=2
sub.l       d5,d4                  ; inc now 4*cols-width bytes
sub.l       d5,d4                  ; *NEW inc now 4*cols-width bytes (wid
move.l      d4,LS.inc(a6)          ; save inc

@dt      move.l      d7,-(sp)

```

- 767 -

Engineering:KlicsCode:CompPict:Color2.a

```

move.l    a6,-(sp)
move.l    LS.row(a6),d7
move.l    PS.Table(a6),a6
UV2RGB4    (a2)+,(a3)+          ; uv2rgb(*U++,*V++)

FETCHY2    (a0)+,d0,d1,d2,d3      ; add Ya to RGB values
FETCHY2    (a1)+,d0,d4,d5,d6      ; add Yb to RGB values

move.l    d1,d0
or.l      d2,d0
or.l      d3,d0
or.l      d4,d0
or.l      d5,d0
or.l      d6,d0
andi.l    #$FF00FF00,d0
bne.w     @over                  ; if overflow

@ok        MKRGB2    d1,d2,d3,a4,d7,d0 ; *NEW save RGBa
           MKRGB2    d4,d5,d6,a5,d7,d0 ; *NEW save RGBb
           move.l    (sp)+,a6
           move.l    (sp)+,d7

           dbf        d7,@do          ; while

           adda.l     LS.inc(a6),a4      ; pm0+=inc
           adda.l     LS.inc(a6),a5      ; pm1+=inc
           adda.l     LS.width(a6),a0    ; Y0+=width
           exg.l      a0,a1              ; Y1<->Y0
           move.l     PS.width(a6),d7    ; count=width
           cmpa.l     LS.fend(a6),a4     ; pm0<fend
           blt.s      @do                ; while

           movem.l    (a7)+,d4-d7/a3-a5 ; restore registers
           unlk       a6                ; remove locals
           rts        ; return

@over      move.l     d7,LS.count(a6)    ; save count
           clr.w      d7                ; AND=0
           FIXOV      d1,d0,d7          ; A overflow
           FIXOV      d2,d0,d7          ; B overflow
           FIXOV      d3,d0,d7          ; A overflow
           FIXOV      d4,d0,d7          ; B overflow
           FIXOV      d5,d0,d7          ; A overflow
           FIXOV      d6,d0,d7          ; B overflow
           move.l     LS.count(a6),d7    ; restore count
           bra        @ok

           ENDFUNC
           -----
           END

```

- 768 -

Engineering:KlincsCode:CompFast:Clut.c

```

/*****
 *
 *  © Copyright 1993 KLICS Limited
 *  All rights reserved.
 *
 *  Written by: Adrian Lewis
 *
 *****/

/*
 *  Analyse CLUT setup and pick appropriate
 *  YUV->RGB converter/display driver. Create
 *  any tables necessary.
 */

#include <QuickDraw.h>
#include <Memory.h>

#define Y_LEVELS    64
#define UV_LEVELS   16

#define absv(v) ((v)<0?-(v):(v))
#define NewPointer(ptr,type,size) \
    saveZone=GetZone(); \
    SetZone(SystemZone()); \
    if (nil==(ptr=(type)NewPtr(size))) { \
        SetZone(ApplicZone()); \
        if (nil==(ptr=(type)NewPtr(size))) { \
            SetZone(saveZone); \
            return(MemoryError()); \
        } \
    } \
    SetZone(saveZone);

typedef struct {
    char    y, u, v;
} YUV_Clut;

/*
 *  unsigned char *
 *  ColourClut(CTabHandle clut)
 *
 */
{
    int      size, y, u, v, r, g, b, i;
    unsigned char *table;
    YUV_Clut  *yuv_clut;

    size=(*clut)->ctSize;
    table=(unsigned char *)NewPtr(Y_LEVELS*UV_LEVELS*UV_LEVELS);
    yuv_clut=(YUV_Clut *)NewPtr(size*sizeof(YUV_Clut));

    for(i=0;i<=size;i++) {
        r=((*clut)->ctTable[i].rgb.red>>8)-128;
        g=((*clut)->ctTable[i].rgb.green>>8)-128;
        b=((*clut)->ctTable[i].rgb.blue>>8)-128;

        yuv_clut[i].y= (306*r + 601*g + 117*b)>>10;
        yuv_clut[i].u= (512*r - 429*g - 83*b)>>10;
        yuv_clut[i].v= (-173*r - 339*g + 512*b)>>10;
    }
    for(y=-Y_LEVELS/2;y<Y_LEVELS/2-1;y++)
        for(u=-UV_LEVELS/2;u<UV_LEVELS/2-1;u++)
            for(v=-UV_LEVELS/2;v<UV_LEVELS/2-1;v++) {
                int      index,error,error2,points, Y, U, V;

```

- 769 -

Engineering:KlicsCode:CompPict:Clut.c

```

    Y=y<<4;
    U=u<<5;
    V=v<<5;

    index=0;
    error=131072;
    error2=131072;
    points=0;
    for(i=0;i<=size;i++) {
        int pts=0, err=0;

        if (yuv_clut[i].y>=Y && yuv_clut[i].y<Y+16)
            pts+=1;
        err+=absv(yuv_clut[i].y-Y);

        if (yuv_clut[i].u>=U && yuv_clut[i].u<U+32)
            pts+=1;
        err+=absv(yuv_clut[i].u-U);

        if (yuv_clut[i].v>=V && yuv_clut[i].v<V+32)
            pts+=1;
        err+=absv(yuv_clut[i].v-V);

        if (pts>points || (pts==points && err<error)) {
            error=err;
            index=i;
            points=pts;
        }
    }
    i=((y&0x1F)<<8)|((u&0xF)<<4)|(v&0xF);
    table[i]=(unsigned char)index;
}
DisposePtr((Ptr)yuv_clut);
return table;
}*/

typedef union {
    long    pixel;
    unsigned char    rgb[4];
} Pixel;
/*
unsigned long *
ColourClut(CTabHandle clut)
{
    long    size, y, u, v, r, g, b, ro, go, bo, i;
    Pixel    *table;

    size=(*clut)->ctSize;
    table=(Pixel *)NewPtr(Y_LEVELS*UV_LEVELS*UV_LEVELS*sizeof(long));

    for(y=-Y_LEVELS/2;y<Y_LEVELS/2-1;y++)
    for(u=-UV_LEVELS/2;u<UV_LEVELS/2-1;u++)
    for(v=-UV_LEVELS/2;v<UV_LEVELS/2-1;v++) {
        Pixel    px;
        long    base, dith;

        r = 32768L + ((y<<9) + 1436L*u <<2);
        g = 32768L + ((y<<9) - 731L*u - 352L*v <<2);
        b = 32768L + ((y<<9) + 1815L*v <<2);

        r=r<0?0:r>65534?65534:r;
        g=g<0?0:g>65534?65534:g;
        b=b<0?0:b>65534?65534:b;
    }
}

```

- 770 -

Engineering:KlicsCode:CompPict:Clut.c

```

    ro=r&13107; r=r/13107;
    go=g&13107; g=g/13107;
    bo=b&13107; b=b/13107;

    base=215-(36*r+6*g+b);

    dith=base-(ro>2621?36:0)-(go>7863?6:0)-(bo>10484?1:0);
    px.rgb[0]=dith==215?255:dith;

    dith=base-(ro>5242?36:0)-(go>10484?6:0)-(bo>2621?1:0);
    px.rgb[1]=dith==215?255:dith;

    dith=base-(ro>7863?36:0)-(go>2621?6:0)-(bo>5242?1:0);
    px.rgb[2]=dith==215?255:dith;

    dith=base-(ro>10484?36:0)-(go>5242?6:0)-(bo>7863?1:0);
    px.rgb[3]=dith==215?255:dith;

    i=((y&0x3F)<<8)|((u&0xF)<<4)|(v&0xF);

    table[i].pixel=px.pixel;
}
return (unsigned long*)table;
}*/

typedef struct {
    long    red, green, blue;
} RGBError;

OSErr ColourClut(Pixel **table)
{
    long    y, u, v, r, g, b, i;
    RGBError *err;
    THz     saveZone;

    NewPointer(*table, Pixel*, Y_LEVELS*UV_LEVELS*UV_LEVELS*sizeof(long)); /* 64k ta
    NewPointer(err, RGBError*, Y_LEVELS*UV_LEVELS*UV_LEVELS*sizeof(RGBError));

    for(i=0; i<4; i++)
        for(y=-Y_LEVELS/2; y<Y_LEVELS/2; y++)
            for(u=-UV_LEVELS/2; u<UV_LEVELS/2; u++)
                for(v=-UV_LEVELS/2; v<UV_LEVELS/2; v++) {
                    RGBColor    src, dst;
                    long    index, in;

                    index=((y&0x3F)<<8)|((u&0xF)<<4)|(v&0xF);

                    r = 32768L + ((y<<9) + (1436L*u) <<2);
                    g = 32768L + ((y<<9) - (731L*u) - (352L*v) <<2);
                    b = 32768L + ((y<<9) + (1815L*v) <<2);

                    if (i>0) {
                        r-=err[index].red;
                        g-=err[index].green;
                        b-=err[index].blue;
                    }

                    src.red=r<0?0:r>65534?65534:r;
                    src.green=g<0?0:g>65534?65534:g;
                    src.blue=b<0?0:b>65534?65534:b;

                    (*table)[index].rgb[i]=(unsigned char)Color2Index(&src);
                }
            }
        }
    }

```

- 771 -

Engineering:KlicsCode:CompPict:Clut.c

```

        Index2Color((*table)[index].rgb[i],&dst);
        err[index].red=dst.red-src.red;
        err[index].green=dst.green-src.green;
        err[index].blue=dst.blue-src.blue;
    )
    DisposePtr((Ptr)err);
    return(noErr);
}

typedef struct {
    short    pel[2];
} Pix16;

typedef struct {
    unsigned char    pel[4];
} Pix8;

#define YS  64
#define UVS 32

OSErr Colour8(Pix8 **table)
{
    long    y, u, v, r, g, b, i;
    RGBError    *err;
    THz        saveZone;

    NewPointer(*table, Pix8*, YS*UVS*UVS*sizeof(Pix8)); /* 128k table */
    NewPointer(err, RGBError*, YS*UVS*UVS*sizeof(RGBError));

    for(i=0; i<4; i++)
        for(y=-YS/2; y<YS/2; y++)
            for(u=-UVS/2; u<UVS/2; u++)
                for(v=-UVS/2; v<UVS/2; v++) {
                    RGBColor    src, dst;
                    long    index;

                    index=(y<<10)|((u&0x1F)<<5)|(v&0x1F);

                    r = 32768L + ((y<<10) + (1436L*u) <<1);
                    g = 32768L + ((y<<10) - (731L*u) - (352L*v) <<1);
                    b = 32768L + ((y<<10) + (1815L*v) <<1);

                    if (i>0) {
                        r-=err[32768+index].red;
                        g-=err[32768+index].green;
                        b-=err[32768+index].blue;
                    }

                    src.red=r<0?0:r>65534?65534:r;
                    src.green=g<0?0:g>65534?65534:g;
                    src.blue=b<0?0:b>65534?65534:b;

                    (*table)[32768+index].pel[i]=(unsigned char)Color2Index(&src);
                    Index2Color((*table)[32768+index].pel[i],&dst);

                    err[32768+index].red=dst.red-src.red;
                    err[32768+index].green=dst.green-src.green;
                    err[32768+index].blue=dst.blue-src.blue;
                }
    DisposePtr((Ptr)err);
    return(noErr);
}

```

- 772 -

Engineering:KlicsCode:CompPact:Clut.c

```

OSErr Colouri16(Pix16 **table)
{
    long    y, u, v, r, g, b, i;
    RGBError *err;
    THz     saveZone;

    NewPointer(*table, Pix16*, YS*UVS*UVS*sizeof(Pix16)); /* 128k table */
    NewPointer(err, RGBError*, YS*UVS*UVS*sizeof(RGBError));

    for(i=0; i<2; i++)
        for(y=-YS/2; y<YS/2; y++)
            for(u=-UVS/2; u<UVS/2; u++)
                for(v=-UVS/2; v<UVS/2; v++) {
                    RGBColor    src, dst;
                    long    index;

                    index=(y<<10)|((u&0x1F)<<5)|(v&0x1F);

                    r = 32768L + ((y<<10) + (1436L*u) <<1);
                    g = 32768L + ((y<<10) - (731L*u) - (352L*v) <<1);
                    b = 32768L + ((y<<10) + (1815L*v) <<1);

                    if (i>0) {
                        r-=err[32768+index].red;
                        g-=err[32768+index].green;
                        b-=err[32768+index].blue;
                    }

                    src.red=r<0?0:r>65534?65534:r;
                    src.green=g<0?0:g>65534?65534:g;
                    src.blue=b<0?0:b>65534?65534:b;

                    dst.red= src.red&0xF800;
                    dst.green= src.green&0xF800;
                    dst.blue= src.blue&0xF800;

                    (*table)[32768+index].pel[i]=(dst.red>>1)|(dst.green>>6)|(dst.blue>>11);

                    err[32768+index].red=dst.red-src.red;
                    err[32768+index].green=dst.green-src.green;
                    err[32768+index].blue=dst.blue-src.blue;
                }
    DisposePtr((Ptr)err);
    return(noErr);
}

Boolean
GreyClut(CTabHandle clut)
{
    Boolean result=true;
    int    i, size;

    size=(*clut)->ctSize;
    for(i=0; i<=size && result; i++) {
        int    r, g, b;

        r=(*clut)->ctTable[i].rgb.red;
        g=(*clut)->ctTable[i].rgb.green;
        b=(*clut)->ctTable[i].rgb.blue;

        result=(r==g && g==b);
    }
}

```

Engineering:KlicsCode:CompPict:Clut.c

return result;

)



- 774 -

Engineering:KlicsCode:CompPict:Bits3.h

```

/*****
 *
 *  © Copyright 1993 KLIICS Limited
 *  All rights reserved.
 *
 *  Written by: Adrian Lewis
 *
 *****/
/*
  Bits3.h: fast bit read/write definitions

  buf_use      define static variables
  buf_winit    initialise vars for write
  buf_rinit    initialise vars for read
  buf_set      set current bit
  buf_get      get current bit
  buf_winc     increment write buffer
  buf_rinc     increment read buffer
  buf_size     fullness of buffer in bytes
  buf_flush    flush buffer

  User defined macro/function buf_over must be defined in case of buffer overflow
*/

typedef struct {
    unsigned long    *buf;
    union {
        unsigned long    mask;
        long            bno;
    } index;
    unsigned long    *ptr, data, size;
} Buffer, *Buf;

#define buf_winit(buf) \
    buf->index.mask=0x80000000; \
    buf->ptr=&buf->buf[0]; \
    buf->data=0;

#define buf_rinit(buf) \
    buf->index.bno=0; \
    buf->ptr=&buf->buf[0];

#define buf_set(buf) \
    buf->data |= buf->index.mask;

#define buf_get(buf) \
    0!=(buf->data & (1<<buf->index.bno))

#define buf_winc(buf) \
    if (buf->index.mask==1) { \
        *buf->ptr=buf->data; \
        buf->data=0; \
        buf->index.mask=0x80000000; \
        buf->ptr++; \
    } else buf->index.mask >>= 1;

#define buf_rinc(buf) \
    if (--(buf->index.bno)<0) { \
        buf->data=*buf->ptr++; \
        buf->index.bno=31; \
    };

/* buf_size only valid after buf_flush */

```

- 775 -

Engineering:KlicsCode:CompPict:Bits3.h

```
#define buf_size(buf) \
    (unsigned char *)buf->ptr-(unsigned char *)&buf->buf[0]

#define buf_flush(buf) \
    if (buf->index.mask!=0x80000000) { \
        buf->data!=buf->index.mask-1; \
        *buf->ptr=buf->data; \
        buf->ptr++; \
    }
```

- 776 -

Engineering:KlricsCode:CompPict:Bits3.a

```

-----
*
*  © Copyright 1993 KLICS Limited
*  All rights reserved.
*
*  Written by: Adrian Lewis
*
-----
*
*  63000 Bit buffer code (Bits2.h)
*
-----
*
*  Macros:
*    buf_winit    &ptr,&data,&mask,&buf
*    buf_rinit    &ptr,&bno,&buf
*    buf_set      &data,&mask
*    buf_get      &data,&bno
*    buf_winc     &ptr,&data,&mask
*    buf_rinc     &ptr,&data,&index
*    buf_flush    &ptr,&data,&mask
*
-----
*
*    macro
*    buf_winit    &ptr,&data,&mask,&buf
*
*    move.l      #$80000000,&mask      ; mask=100...
*    move.l      &buf,&ptr              ; ptr=buf
*    clr.l       &data                 ; data=0
*
*    endm
*
-----
*
*    macro
*    buf_rinit    &ptr,&bno,&buf
*
*    clr.b       &bno                  ; bno=0
*    move.l      &buf,&ptr              ; ptr=buf
*
*    endm
*
-----
*
*    macro
*    buf_set      &data,&mask
*
*    or.l        &mask,&data            ; data |= mask
*
*    endm
*
-----
*
*    macro
*    buf_get      &data,&bno
*
*    subq.b      #1,&bno
*    btst        &bno,&data
*
*    endm
*
-----
*
*    macro
*    buf_winc     &ptr,&data,&mask
*
*    lsr.l       #1,&mask                ; mask>>=1
*    bne.s       @cont                  ; if non-zero continue
*    move.l      &data,(&ptr)+          ; *ptr++=data
*    clr.l       &data                  ; data=0
*    move.l      #$80000000,&mask        ; mask=100...

```

- 777 -

Engineering:KlicsCode:CompPict:Bits3.a

```

@cont
*
    endm
*-----*
    macro
    buf_rinc    &ptr,&data,&bno
*
    cmpi.b      #16,&bno
    bge.s       @cont
    swap        &data
    move.w      (&ptr)+,&data      ; data=*ptr++
    add.b       #16,&bno           ; bno+=16
@cont
*
    endm
*-----*
    macro
    buf_flush   &ptr,&data,&mask
*
    cmp.l       #$80000000,&mask    ; mask=8000000?
    beq.s       @cont              ; if buffer empty continue
    move.l      &data,(&ptr)+      ; *ptr++=data
*
    endm
*-----*

```

- 778 -

Engineering:KlicsCode:CompPict:Backward.c

```

/*****
 *
 *  © Copyright 1993 KLICS Limited
 *  All rights reserved.
 *
 *  Written by: Adrian Lewis
 *
 *****/
/*
  Extra fast Backward\convolver
  New wavelet coeffs : 3 5 1 1, 1 2 1, 1 1

  Optimized for speed:
    dirn - False
    src/dst octave == 0
*/

#define BwdS0(addr0,dAG,dAH,dBH) \
    v=(short *)addr0; \
    dAG= -v; \
    dAH= v; \
    dBH= v<<1; \

#define BwdS1(addr1,addr0,dAG,dAH,dBH) \
    v=(short *)addr1; \
    dBH+= v>>1; \
    dAG+= v+(vs=v<<1); \
    dAH-= v+(vs<=1); \
    *(short *)addr0=dBH>>1;

#define Bwd2(addr2,dAG,dAH,dBG,dBH) \
    v=(short *)addr2; \
    dBG= -v; \
    dBH= v; \
    dAH+= v+(vs=v<<1); \
    dAG+= v+(vs<=1);

#define Bwd3(addr3,addr2,addr1,dAG,dAH,dBG,dBH) \
    v=(short *)addr3; \
    dAH+= v; \
    dAG+= v; \
    dBG+= v+(vs=v<<1); \
    dBH-= v+(vs<=1); \
    *(short *)addr1=(dAH+1)>>2; \
    *(short *)addr2=(dAG+1)>>2;

#define Bwd0(addr0,dAG,dAH,dBG,dBH) \
    v=(short *)addr0; \
    dAG= -v; \
    dAH= v; \
    dBH+= v+(vs=v<<1); \
    dBG+= v+(vs<=1);

#define Bwd1(addr1,addr0,addr3,dAG,dAH,dBG,dBH) \
    v=(short *)addr1; \
    dBH+= v; \
    dBG+= v; \
    dAG+= v+(vs=v<<1); \
    dAH-= v+(vs<=1); \
    *(short *)addr3=(dBH+1)>>2; \
    *(short *)addr0=(dBG+1)>>2;

#define BwdE2(addr2,dAG,dAH,dBH) \

```

- 779 -

Engineering:KlicsCode:CompPict:Backward.c

```

v=(short *)addr2; \
dBH= vs=v<<1; \
dAH+= v+(vs=v<<1); \
dAG+= v+(vs<=1);

#define BwdE3(addr3,addr2,addr1,dAG,dAH,dBH) \
v=(short *)addr3; \
dAH+= v; \
dAG+= v; \
dBH-= v+(vs=v<<1); \
dBH-= v+(vs<=1); \
*(short *)addr1=(dAH+1)>>2; \
*(short *)addr2=(dAG+1)>>2; \
*(short *)addr3=dBH>>1;

#define Bwd(base,end,inc) \
addr0=base; \
addr3=addr0-(inc>>2); \
addr2=addr3-(inc>>2); \
addr1=addr2-(inc>>2); \
BwdS0(addr0,dAG,dAH,dBH); \
addr1+=inc; \
BwdS1(addr1,addr0,dAG,dAH,dBH); \
addr2+=inc; \
while(addr2<end) { \
    Bwd2(addr2,dAG,dAH,dBG,dBH); \
    addr3+=inc; \
    Bwd3(addr3,addr2,addr1,dAG,dAH,dBG,dBH); \
    addr0+=inc; \
    Bwd0(addr0,dAG,dAH,dBG,dBH); \
    addr1+=inc; \
    Bwd1(addr1,addr0,addr3,dAG,dAH,dBG,dBH); \
    addr2+=inc; \
} \
BwdE2(addr2,dAG,dAH,dBH); \
addr3+=inc; \
BwdE3(addr3,addr2,addr1,dAG,dAH,dBH);

#define BwdS0r2(addr0,dAG,dAH,dBH) \
v=(short *)addr0; \
dAG= 0; \
dAH= v; \
dBH= v; \

#define BwdS1r2(addr1,addr0,dAG,dAH,dBH) \
v=(short *)addr1; \
dBH+= v>>2; \
dAG+= v; \
dAH-= v<<1; \
*(short *)addr0=dBH;

#define Bwd2r2(addr2,dAG,dAH,dBG,dBH) \
v=(short *)addr2; \
dBG= 0; \
dBH= v; \
dAH+= v; \
dAG+= v<<1;

#define Bwd3r2(addr3,addr2,addr1,dAG,dAH,dBG,dBH) \
v=(short *)addr3; \
dAH+= 0; \
dAG+= v; \
dBG+= v; \

```

- 780 -

Engineering:KlacsCode:CompPict:Backward.c

```

    dBH-= v<<1; \
    *(short *)addr1=dAH>>1; \
    *(short *)addr2=dAG>>1;

#define Bwd0r2(addr0,dAG,dAH,dBG,dBH) \
    v=(short *)addr0; \
    dAG= 0; \
    dAH= v; \
    dBH+= v; \
    dBG+= v<<1;

#define Bwd1r2(addr1,addr0,addr3,dAG,dAH,dBG,dBH) \
    v=(short *)addr1; \
    dBH+= 0; \
    dBG+= v; \
    dAG+= v; \
    dAH-= v<<1; \
    *(short *)addr3=dBH>>1; \
    *(short *)addr0=dBG>>1;

#define BwdE2r2(addr2,dAG,dAH,dBH) \
    v=(short *)addr2; \
    dBH= v; \
    dAH+= v; \
    dAG+= v<<1;

#define BwdE3r2(addr3,addr2,addr1,dAG,dAH,dBH) \
    v=(short *)addr3; \
    dAH+= 0; \
    dAG+= v; \
    dBH-= v; \
    dBH-= v<<1; \
    *(short *)addr1=dAH>>1; \
    *(short *)addr2=dAG>>1; \
    *(short *)addr3=dBH;

#define Bwdr2(base,end,inc) \
    addr0=base; \
    addr3=addr0-(inc>>2); \
    addr2=addr3-(inc>>2); \
    addr1=addr2-(inc>>2); \
    BwdS0r2(addr0,dAG,dAH,dBH); \
    addr1+=inc; \
    BwdS1r2(addr1,addr0,dAG,dAH,dBH); \
    addr2+=inc; \
    while(addr2<end) { \
        Bwd2r2(addr2,dAG,dAH,dBG,dBH); \
        addr3+=inc; \
        Bwd3r2(addr3,addr2,addr1,dAG,dAH,dBG,dBH); \
        addr0+=inc; \
        Bwd0r2(addr0,dAG,dAH,dBG,dBH); \
        addr1+=inc; \
        Bwd1r2(addr1,addr0,addr3,dAG,dAH,dBG,dBH); \
        addr2+=inc; \
    } \
    BwdE2r2(addr2,dAG,dAH,dBH); \
    addr3+=inc; \
    BwdE3r2(addr3,addr2,addr1,dAG,dAH,dBH);

#define BwdS0r3(addr0,dAG,dAH,dBH) \
    v=(short *)addr0; \
    dAG= 0; \
    dAH= 0; \

```

Engineering:KlicsCode:CompPict:Backward.c

```

    dBH= v>>1; \

#define BwdSlr3(addr1,addr0,dAG,dAH,dBH) \
    v=*(short *)addr1; \
    dBH+= v>>3; \
    dAG+= v; \
    dAH-= v; \
    *(short *)addr0=dBH<<1;

#define Bwd2r3(addr2,dAG,dAH,dBG,dBH) \
    v=*(short *)addr2; \
    dBG= 0; \
    dBH= 0; \
    dAH+= v; \
    dAG+= v;

#define Bwd3r3(addr3,addr2,addr1,dAG,dAH,dBG,dBH) \
    v=*(short *)addr3; \
    dAH+= 0; \
    dAG+= 0; \
    dBG+= v; \
    dBH-= v; \
    *(short *)addr1=dAH; \
    *(short *)addr2=dAG;

#define Bwd0r3(addr0,dAG,dAH,dBG,dBH) \
    v=*(short *)addr0; \
    dAG= 0; \
    dAH= 0; \
    dBH+= v; \
    dBG+= v;

#define Bwd1r3(addr1,addr0,addr3,dAG,dAH,dBG,dBH) \
    v=*(short *)addr1; \
    dBH+= 0; \
    dBG+= 0; \
    dAG+= v; \
    dAH-= v; \
    *(short *)addr3=dBH; \
    *(short *)addr0=dBG;

#define BwdE2r3(addr2,dAG,dAH,dBH) \
    v=*(short *)addr2; \
    dBH= v>>1; \
    dAH+= v; \
    dAG+= v;

#define BwdE3r3(addr3,addr2,addr1,dAG,dAH,dBH) \
    v=*(short *)addr3; \
    dAH+= 0; \
    dAG+= 0; \
    dBH-= v; \
    dBH-= v; \
    *(short *)addr1=dAH; \
    *(short *)addr2=dAG; \
    *(short *)addr3=dBH<<1;

#define Bwdr3(base,end,inc) \
    addr0=base; \
    addr3=addr0-(inc>>2); \
    addr2=addr3-(inc>>2); \
    addr1=addr2-(inc>>2); \
    BwdS0r3(addr0,dAG,dAH,dBH); \

```



- 782 -

Engineering:KlicsCode:CompPict:Backward.c

```

addr1+=inc; \
BwdSir3(addr1,addr0,dAG,dAH,dBH); \
addr2+=inc; \
while(addr2<end) { \
    Bwd2r3(addr2,dAG,dAH,dBG,dBH); \
    addr3-=inc; \
    Bwd3r3(addr3,addr2,addr1,dAG,dAH,dBG,dBH); \
    addr0+=inc; \
    Bwd0r3(addr0,dAG,dAH,dBG,dBH); \
    addr1+=inc; \
    Bwd1r3(addr1,addr0,addr3,dAG,dAH,dBG,dBH); \
    addr2+=inc; \
} \
BwdE2r3(addr2,dAG,dAH,dBH); \
addr3+=inc; \
BwdE3r3(addr3,addr2,addr1,dAG,dAH,dBH);

extern void FASTBACKWARD(char *data, long incl, long loop1, long inc2, char *end2)
extern void HAARBACKWARD(char *data, long incl, long loop1, long inc2, long loop2)
extern void HAARTOPBWD(char *data, long height, long width);
/* extern void HAARXTOPBWD(char *data, long area); */

void    FasterBackward(char *data, long incl, long endl, long inc2, char *end2)
{
    register short  v, vs, v3, dAG, dAH, dBG, dBH, inc;
    register char   *addr0, *addr1, *addr2, *addr3, *end;
    char            *base;

    inc=incl;
    for(base=data;base<end2;base+=inc2) {
        end=base+endl;
        Bwd(base,end,inc);
    }
}

extern void    TOPBWD(char *data, char *dst, long size_1, long size_0);

void    TestTopBackward(short *data,int size[2],int oct_src)
{
    int      oct, area=size[0]*size[1]<<1;
    short    width=size[0]<<1;
    char      *top=area+(char *)data, *left=width+(char *)data;

    for(oct=oct_src-1;oct>0;oct--) {
        long    cinc=2<<oct, cinc4=cinc<<2,
                rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in t

        FASTBACKWARD((char *)data,rinc4,area-(rinc<<1),cinc,left);
        FASTBACKWARD((char *)data,cinc4,width-(cinc<<1),rinc,top);
    }
    /* FasterBackward((char *)data,size[0]<<3,area-(size[0]<<2),2,left);
    FasterBackward((char *)data,8,width-4,size[0]<<1,top); */
    TOPBWD((char *)data,(char *)data,size[0],size[1]);
}

void    TestBackward(data,size,oct_src)

short    *data;
int      size[2], oct_src;

{
    int      oct, area=size[0]*size[1]<<1;
    short    width=size[0]<<1;
    char      *top=area+(char *)data, *left=width+(char *)data;

```

- 783 -

Engineering:KlicsCode:CompPict:Backward.c

```

for(oct=oct_src-1;oct>=0;oct--) {
    long    cinc=2<<oct, cinc4=cinc<<2,
            rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in t

    FasterBackward((char *)data,rinc4,area-(rinc<<1),cinc,left);
    FasterBackward((char *)data,cinc4,width-(cinc<<1),rinc,top);
}

void    Backward3511(data,size,oct_src)
short    *data;
int    size[2], oct_src;

{
    int    oct, area=size[0]*size[1]<<1;
    short    width=size[0]<<1;
    char    *top=area+(char *)data, *left=width+(char *)data;

    for(oct=oct_src-1;oct>0;oct--) {
        long    cinc=2<<oct, cinc4=cinc<<2,
                rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in t

        BACK3511((char *)data,rinc4,area-(rinc<<1),cinc,left);
        BACK3511((char *)data,cinc4,width-(cinc<<1),rinc,top);
    }
    BACK3511V((char *)data,size[0]<<3,area-(size[0]<<2),4,left);
    BACK3511H((char *)data,8,width-4,size[0]<<1,top);
    /* TOPBWD((char *)data,(char *)data,size[1],size[0]);*/
}

```

Engineering:KlicsCode:CompPict:Backward.a

```

-----
*
*   © Copyright 1993 KLICS Limited
*   All rights reserved.
*
*   Written by: Adrian Lewis
*
-----
*
*   680X0 3511 Backward code
*
*   Coeffs 11 19 5 3
*   become 3 5 1 1
*
-----
*
*   seg      'klics'
*
-----
*
*   macro
*   BwdStart0    &addr0,&dAG,&dAH,&dBH
*
*   move.w      (&addr0),&dAH    ; dAH=(short *)addr0
*   move.w      &dAH,&dAG        ; dAG=v
*   neg.w       &dAG            ; dAG=-dAG
*   move.w      &dAH,&dBH        ; dBH=v
*   add.w       &dBH,&dBH        ; dBH=v<<1
*
*   endm
*
*   macro
*   BwdStart1    &addr1,&addr0,&dAG,&dAH,&dBH
*
*   move.w      (&addr1),d0      ; v=(short *)addr1
*   move.w      d0,d1            ; vs=v
*   asr.w       #1,d1            ; vs=v>>1
*   add.w       d1,&dBH          ; dBH+= v>>1
*   add.w       d0,&dAG          ; dAG+=v
*   sub.w       d0,&dAH          ; dAH-=v
*   add.w       d0,d0            ; v<<=1
*   add.w       d0,&dAG          ; dAG+=2v
*   add.w       d0,d0            ; v<<=1
*   sub.w       d0,&dAH          ; dAH-=4v
*   asr.w       #1,&dBH          ; dBH>>=1
*   move.w      &dBH,(&addr0)    ; *(short *)addr0=dBH
*
*   endm
*
*   macro
*   BwdEven &addr2,&dAG,&dAH,&DBG,&dBH
*
*   move.w      (&addr2),d0      ; v=(short *)addr2
*   move.w      d0,&dBH          ; dBH=v
*   move.w      d0,&DBG          ; DBG=v
*   neg.w       &DBG            ; DBG=-v
*   add.w       d0,&dAH          ; dAH+=v
*   add.w       d0,&dAG          ; dAG+=v
*   add.w       d0,d0            ; 2v
*   add.w       d0,&dAH          ; dAH+=v
*   add.w       d0,d0            ; 2v
*   add.w       d0,&dAG          ; dAH+=v
*
*   endm
*
*   macro

```

- 785 -

Engineering:KlicsCode:CompPict:Backward:a

```

BwdOdd      &addr3,&addr2,&addr1,&dAG,&dAH,&DBG,&DBH

move.w      (&addr3),d0      ; v=(short *)addr3

add.w       d0,&dAH           ; dAH+=v
add.w       d0,&dAG           ; dAG+=v
add.w       d0,&DBG           ; DBG+=v
sub.w       d0,&DBH           ; DBH-=v
add.w       d0,d0            ; 2v
add.w       d0,&DBG           ; DBG+=v
add.w       d0,d0            ; 4v
sub.w       d0,&DBH           ; DBH-=4v

asr.w       #2,&dAH           ; dAH>>=2
move.w      &dAH,(&addr1)     ; *(short *)addr1=dAH
asr.w       #2,&dAG           ; dAG>>=2
move.w      &dAG,(&addr2)     ; *(short *)addr2=dAG

endm
-----
macro
BwdEnd2      &addr2,&dAG,&dAH,&DBH

move.w      (&addr2),d0      ; v=(short *)addr2

add.w       d0,&dAH           ; dAH+=v
add.w       d0,&dAG           ; dAG+=v
add.w       d0,d0            ; 2v
move.w      d0,&DBH           ; DBH=2v
add.w       d0,&dAH           ; dAH+=2v
add.w       d0,d0            ; 4v
add.w       d0,&dAG           ; dAG+=4v

endm
-----
macro
BwdEnd3      &addr3,&addr2,&addr1,&dAG,&dAH,&DBH

move.w      (&addr3),d0      ; v=(short *)addr3
add.w       d0,&dAH           ; dAH+=v
add.w       d0,&dAG           ; dAG+=v
lsl.w       #3,d0            ; 8v
sub.w       d0,&DBH           ; DBH-=8v
asr.w       #2,&dAH           ; dAH>>=2
move.w      &dAH,(&addr1)     ; *(short *)addr1=dAH
asr.w       #2,&dAG           ; dAG>>=2
move.w      &dAG,(&addr2)     ; *(short *)addr2=dAG
asr.w       #1,&DBH           ; DBH>>=1
move.w      &DBH,(&addr3)     ; *(short *)addr3=DBH

endm
-----
macro
Bwd          &base,&end,&inc

movea.l     &base,a0          ; addr0=base
move.l      &inc,d0           ; d0=inc
asr.l       #2,d0             ; d0=inc>>2
movea.l     a0,a3             ; addr3=addr0
suba.l      d0,a3             ; addr3-=inc>>2
movea.l     a3,a2             ; addr2=addr3
suba.l      d0,a2             ; addr2-=inc>>2
movea.l     a2,a1             ; addr1=addr2

```

- 786 -

Engineering:KlicsCode:CompPict:Backward.a

```

suba.l    d0,a1                ; addr1--(inc>>2)
BwdStart0 a0,d1,d5,d7          ; BwdStart0(addr0,dAG,dAH,dBH)
adda.l    &inc,a1              ; addr1+=inc
BwdStart1 a1,a0,d4,d5,d7       ; BwdStart1(addr1,addr0,dAG,dAH,dBH)
adda.l    &inc,a2              ; addr2+=inc
?do       BwdEven              ; BwdEven(addr2,dAG,dAH,dBG,dBH)
adda.l    &inc,a3              ; addr3+=inc
BwdOdd    a3,a2,a1,d4,d5,d6,d7 ; BwdOdd(addr3,addr2,addr1,dAG,dAH,dBG)
adda.l    &inc,a0              ; addr0+=inc
BwdEven    a0,d6,d7,d4,d5      ; BwdEven(addr0,dBG,dBH,dAG,dAH)
adda.l    &inc,a1              ; addr1+=inc
BwdOdd    a1,a0,a3,d6,d7,d4,d5 ; BwdOdd(addr1,addr0,addr3,dBG,dBH,dAG)
adda.l    &inc,a2              ; addr2+=inc
cmpa.l    a2,&end              ; addr2<end
bgt.s     @do                 ; while
BwdEnd2    a2,d4,d5,d7         ; BwdEnd2(addr2,dAG,dAH,dBH)
adda.l    &inc,a3              ; addr3+=inc
BwdEnd3    a3,a2,a1,d4,d5,d7   ; BwdEnd3(addr3,addr2,addr1,dAG,dAH,dB

```

endm

-----

Back3511      FUNC      EXPORT

```

PS        RECORD        8
data      DS.L          1
inc1      DS.L          1
end1      DS.L          1
inc2      DS.L          1
end2      DS.L          1
          ENDR

```

```

link        a6,#0                    ; no local variables
movem.l     d4-d7/a3-a5,-(a7)        ; store registers

move.l      PS.inc1(a6),d3           ; inc=inc1
movea.l     PS.data(a6),a5           ; base=data
@do        movea.l     a5,a4           ; end=base
adda.l      PS.end1(a6),a4           ; end+=end1
Bwd        a5,a4,d3                ; Bwd(base,end,inc)
adda.l      PS.inc2(a6),a5           ; base+=inc2
cmpa.l      PS.end2(a6),a5           ; end2>base
blt.w       @do                    ; for

movem.l     (a7)+,d4-d7/a3-a5        ; restore registers
unlk        a6                    ; remove locals
rts                                ; return

```

ENDFUNC

-----

```

macro
BwdStartV0 &addr0,&dAG,&dAH,&dBH

```

```

move.l      (&addr0),&dAH        ; dAH=*(short *)&addr0
move.l      &dAH,&dAG            ; dAG=v
neg.l       &dAG                ; dAG=-dAG
move.l      &dAH,&dBH            ; dBH=v
add.l       &dBH,&dBH            ; dBH=v<<1

```

endm

-----

```

macro
BwdStartV1 &addr1,&addr0,&dAG,&dAH,&dBH

```

- 787 -

Engineering:KlicsCode:CompPict:Backward.a

```

move.l    (&addr1),d0      ; v=*(short *)addr1
move.l    d0,d1            ; vs=v
asr.l     #1,d1            ; vs=v>>1
add.l     d1,&dBH          ; dBH+= v>>1
add.l     d0,&dAG          ; dAG+=v
sub.l     d0,&dAH          ; dAH-=v
add.l     d0,d0            ; v<<=1
add.l     d0,&dAG          ; dAG+=2v
add.l     d0,d0            ; v<<=1
sub.l     d0,&dAH          ; dAH-=4v

asr.l     #1,&dBH          ; dBH>>=1
add.w     &dBH,&dBH        ; shift word back
asr.w     #1,&dBH          ; dBH>>=1
move.l    &dBH,(&addr0)    ; *(short *)addr0=dBH
endm
-----
macro
BwdEvenV    &addr2,&dAG,&dAH,&DBG,&dBH

move.l    (&addr2),d0      ; v=*(short *)addr2
move.l    d0,&dBH          ; dBH=v
move.l    d0,&DBG          ; DBG=v
neg.l     &DBG             ; DBG=-v
add.l     d0,&dAH          ; dAH+=v
add.l     d0,&dAG          ; dAG+=v
add.l     d0,d0            ; 2v
add.l     d0,&dAH          ; dAH+=v
add.l     d0,d0            ; 2v
add.l     d0,&dAG          ; dAG+=v

endm
-----
macro
BwdOddV     &addr3,&addr2,&addr1,&dAG,&dAH,&DBG,&dBH

move.l    (&addr3).d0     ; v=*(short *)addr3

add.l     d0,&dAH          ; dAH+=v
add.l     d0,&dAG          ; dAG+=v
add.l     d0,&DBG          ; DBG+=v
sub.l     d0,&dBH          ; dBH-=v
add.l     d0,d0            ; 2v
add.l     d0,&DBG          ; DBG+=v
add.l     d0,d0            ; 4v
sub.l     d0,&dBH          ; dBH-=4v

asr.l     #2,&dAH          ; dAH>>=2
lsl.w     #2,&dAH          ; shift word back
asr.w     #2,&dAH          ; dAH>>=2
move.l    &dAH,(&addr1)    ; *(short *)addr1=dAH
asr.l     #2,&dAG          ; dAG>>=2
lsl.w     #2,&dAG          ; shift word back
asr.w     #2,&dAG          ; dAG>>=2
move.l    &dAG,(&addr2)    ; *(short *)addr2=dAG

endm
-----
macro
BwdEndV2    &addr2,&dAG,&dAH,&dBH

move.l    (&addr2).d0     ; v=*(short *)addr2

```

- 788 -

Engineering:KlicsCode:CompPict:Backward.a

```

add.l    d0,&dAH      ; dAH+=v
add.l    d0,&dAG      ; dAG+=v
add.l    d0,d0        ; 2v
move.l   d0,&dBH      ; dBH=2v
add.l    d0,&dAH      ; dAH+=2v
add.l    d0,d0        ; 4v
add.l    d0,&dAG      ; dAG+=4v

```

```

endm

```

```

macro
BwdEndV3    &addr3,&addr2,&addr1,&dAG,&dAH,&dBH

move.l     (&addr3),d0      ; v="(short *)addr3
add.l      d0,&dAH          ; dAH+=v
add.l      d0,&dAG          ; dAG+=v
lsl.l      #3,d0            ; 8v
sub.l      d0,&dBH          ; dBH-=8v
asr.l      #2,&dAH          ; dAH>>=2
lsl.w      #2,&dAH          ; shift word back
asr.w      #2,&dAH          ; dAH>>=2
move.l     &dAH,(&addr1)    ; *(short *)addr1=dAH
asr.l      #2,&dAG          ; dAG>>=2
lsl.w      #2,&dAG          ; shift word back
asr.w      #2,&dAG          ; dAG>>=2
move.l     &dAG,(&addr2)    ; *(short *)addr2=dAG
asr.l      #1,&dBH          ; dBH>>=1
lsl.w      #1,&dBH          ; shift word back
asr.w      #1,&dBH          ; dBH>>=2
add.l      &dBH,&dBH        ; dBH<<=1
move.l     &dBH,(&addr3)    ; *(short *)addr3=dBH

```

```

endm

```

```

macro
BwdV        &base,&end,&inc

```

```

movea.l    &base,a0          ; addr0=base
move.l     &inc,d0           ; d0=inc
asr.l      #2,d0             ; d0=inc>>2
movea.l    a0,a3             ; addr3=addr0
suba.l     d0,a3             ; addr3-=(inc>>2)
movea.l    a3,a2             ; addr2=addr3
suba.l     d0,a2             ; addr2-=(inc>>2)
movea.l    a2,a1             ; addr1=addr2
suba.l     d0,a1             ; addr1-=(inc>>2)
BwdStartV0 a0,d4,d5,d7       ; BwdStart0(addr0,dAG,dAH,dBH)
adda.l     &inc,a1           ; addr1+=inc
BwdStartV1 a1,a0,d4,d5,d7    ; BwdStart1(addr1,addr0,dAG,dAH,dBH)
adda.l     &inc,a2           ; addr2+=inc
@do        BwdEvenV         a2,d4,d5,d6,d7 ; BwdEven(addr2,dAG,dAH,dBG,dBH)
adda.l     &inc,a3           ; addr3+=inc
BwdOddV    a3,a2,a1,d4,d5,d6,d7 ; BwdOdd(addr3,addr2,addr1,dAG,dAH,dBG)
adda.l     &inc,a0           ; addr0+=inc
BwdEvenV    a0,d6,d7,d4,d5    ; BwdEven(addr0,dBG,dBH,dAG,dAH)
adda.l     &inc,a1           ; addr1+=inc
BwdOddV    a1,a0,a3,d6,d7,d4,d5 ; BwdOdd(addr1,addr0,addr3,dBG,dBH,dAG)
adda.l     &inc,a2           ; addr2+=inc
cmpa.l     a2,&end           ; addr2<end
bgt.s      @do              ; while
BwdEndV2    a2,d4,d5,d7      ; BwdEnd2(addr2,dAG,dAH,dBH)
adda.l     &inc,a3           ; addr3+=inc

```

- 789 -

Engineering:KlicsCode:CompPict:Backward.a

```

BwdEndV3      a3,a2,a1,d4,d5,d7      ; BwdEnd3(addr3,addr2,addr1,dAG,dAH,dB
endm
-----
Back3511V     FUNC      EXPORT
PS            RECORD      8
data          DS.L        1
incl          DS.L        1
endl          DS.L        1
inc2          DS.L        1
end2          DS.L        1
ENDR

link          a6,#0
movem.1       d4-d7/a3-a5,-(a7)      ; no local variables
                                         ; store registers

move.1        PS.inc1(a6),d3          ; inc=incl
movea.1       PS.data(a6),a5          ; base=data
3do           movea.1       a5,a4      ; end=base
adda.1        PS.end1(a6),a4          ; end+=endl
BwdV          a5,a4,d3                ; Bwd(base,end,inc)
adda.1        PS.inc2(a6),a5          ; base+=inc2
cmpa.1        PS.end2(a6),a5          ; end2>base
blt.w         @do                     ; for

movem.1       (a7)+,d4-d7/a3-a5      ; restore registers
unlk          a6                      ; remove locals
rts           ; return

ENDFUNC
-----
macro
BwdStarth     &addrR,&A,&C

move.1        (&addrR)+,&A          ; 1H1G=*(long *)&addrR
move.1        &A,d0                  ; A=1H1G, d0=1H1G
move.1        &A,&C                  ; A=1H1G, d0=1H1G, C=1H1G
add.w         &A,d0                  ; A=1H1G, d0=1H2G, C=1H1G
add.w         d0,&A                  ; A=1H3G, d0=1H2G, C=1H1G
add.w         &A,d0                  ; A=1H3G, d0=1H5G, C=1H1G
swap          &A                     ; A=3GH1, d0=1H5G, C=1H1G
sub.1         d0,&A                  ; A=AAAA, d0=1H5G, C=1H1G

endm
-----
macro
BwdCycleH     &addrR,&addrW,&A,&B,&C

move.1        (&addrR)+,&B          ; 1H1G=*(long *)&addrR
move.1        &B,d0                  ; B=1H1G, d0=1H1G
add.1         d0,d0                  ; B=1H1G, d0=2H2G
move.1        d0,d1                  ; B=1H1G, d0=2H2G, d1=2H2G
add.1         &B,d0                  ; B=1H1G, d0=3H3G, d1=2H2G
add.1         d0,d1                  ; B=1H1G, d0=3H3G, d1=5H5G
move.1        &B,d2                  ; B=1H1G, d0=3H3G, d1=5H5G, d2=1H1G
move.w        d1,d2                  ; B=1H1G, d0=3H3G, d1=5H5G, d2=1H5G
move.w        &B,d1                  ; B=1H1G, d0=3H3G, d1=5H1G, d2=1H5G
move.w        d0,&B                  ; B=1H3G, d0=3H3G, d1=5H1G, d2=1H5G
move.w        d1,d0                  ; B=1H3G, d0=3H1G, d1=5H1G, d2=1H5G
swap          &B                     ; B=3G1H, d0=3H1G, d1=5H1G, d2=1H5G
swap          d0                     ; B=3G1H, d0=1G3H, d1=5H1G, d2=1H5G

```



- 790 -

Engineering:KlicsCode:CompPict:Backward.a

```

sub.l      d2,&B      ; B=3G1H-1H5G
add.l      d0,&A      ; A+=1H3G
add.l      d1,&A      ; A+=5G1H

asr.w      #2,&A      ; A0>>=2
move.w     &A,&C      ; C complete
asr.l      #2,&A      ; A1>>=2
move.l     &C,(&addrW)+ ; *(long *)addrW=DD
move.l     &A,&C      ; C=A1XX

endm

-----
macro
BwdEndH      &addrR,&addrW,&A,&B,&C

move.l      (&addrR)+,d0 ; 1H1G=*(long *)addrR
move.w     d0,d2      ; d2=1G
lsl.w      #2,d2      ; d2=4G
neg.w      d2      ; d2=-4G
swap       d0      ; d0=1G1H
add.w      d0,d2      ; d2+=-1H
move.l     d0,d1      ; d0=1G1H, d1=1G1H
add.w      d0,d1      ; d0=1G1H, d1=1G2H
add.w      d1,d0      ; d0=1G3H, d1=1G2H
add.w      d0,d1      ; d0=1G3H, d1=1G5H
swap       d1      ; d0=1G3H, d1=5H1G
add.l      d0,&A      ; A+=1G3H
add.l      d1,&A      ; A+=5H1G

asr.w      #2,&A      ; A1>>=2
move.w     &A,&C      ; C complete
asr.l      #2,&A      ; A0>>=2
move.l     &C,(&addrW)+ ; *(long *)addrW=C
move.w     d2,&A      ; A=D1D2
move.l     &A,(&addrW)+ ; *(long *)addrW=A

endm

-----
macro
BwdH      &base,&end,&inc

movea.l     &base,a0      ; addrR=base
movea.l     a0,a1      ; addrW=addrR
BwdStartH   a0,d3,d5      ; BwdStart(addrR,A,DD)
@do
BwdCycleH   a0,a1,d3,d4,d5 ; BwdCycle(addrR,addrW,A,B,C)
BwdCycleH   a0,a1,d4,d3,d5 ; BwdCycle(addrR,addrW,B,A,C)
cmpa.l      a0,&end      ; addr2<end
bgt.s       @do          ; while
BwdEndH     a0,a1,d3,d4,d5 ; BwdEnd(addrR,addrW,A,B,DD)

endm

-----
Back3511H   FUNC      EXPORT
PS          RECORD     8
data        DS.L       1
inc1        DS.L       1
end1        DS.L       1
inc2        DS.L       1
end2        DS.L       1
ENDR

link        a6,#0      ; no local variables

```

- 791 -

Engineering:KlicsCode:CompPict:Backward.a

Page 8

```
      movem.l    d4-d7/a3-a5,-(a7)      ; store registers
      move.l     PS.incl(a6);d3          ; inc=inc1
      movea.l    PS.data(a6),a5         ; base=data
@do    movea.l    a5,a4                  ; end=base
      adda.l     PS.end1(a6),a4          ; end+=end1
      BwdH       a5,a4,d3               ; Bwd(base,end,inc)
      adda.l     PS.inc2(a6),a5          ; base+=inc2
      cmpa.l     PS.end2(a6),a5         ; end2>base
      blt.w      @do                    ; for

      movem.l    (a7)+,d4-d7/a3-a5      ; restore registers
      unlk       a6                     ; remove locals
      rts                            ; return

      ENDFUNC
-----
      END
```

- 792 -

Engineering:KlicsCode:CompPict:KlicsEnc.c

```

/*****
 *
 *  © Copyright 1993 KLICS Limited
 *  All rights reserved.
 *
 *  Written by: Adrian Lewis
 *
 *****/
/*
 *  Full still/video Knowles-Lewis Image KlicsEncode System utilising HVS properti
 *  and delta-tree coding
 *
 *  Recoded and re-rationalised (Stand alone version)
 */

#include <FixMath.h>
#include "Bits3.h"
#include "Klics.h"
#include "KlicsHeader.h"
#include "KlicsEncode.h"

#include <Math.h>

/* If bool true the negate value */
#define negif(bool,value) ((bool)?-(value):(value))
#define abs(value) negif(value<0,value)

extern void HaarForward();
extern void Daub4Forward();

/* Use the bit level file macros (Bits2.h)
buf_use;*/

/* Huffman encode a block */
#define HuffEncLev(lev,buf) \
    HuffEncode(lev[0],buf); \
    HuffEncode(lev[1],buf); \
    HuffEncode(lev[2],buf); \
    HuffEncode(lev[3],buf);

/* Fixed length encode block of integers */
#define IntEncLev(lev,lpf_bits,buf) \
    IntEncode(lev[0],lpf_bits,buf); \
    IntEncode(lev[1],lpf_bits,buf); \
    IntEncode(lev[2],lpf_bits,buf); \
    IntEncode(lev[3],lpf_bits,buf);

/* Define write a zero */
#define Token0 \
    buf_winc(buf);

/* Define write a one */
#define Token1 \
    buf_set(buf); buf_winc(buf);

/* Write block for data and update memory */
#define DoXfer(addr,pro,lev,dst,mode,oct,nmode,buf) \
    HuffEncLev(lev,buf); \
    PutData(addr,pro,dst); \
    mode[oct]=oct==0?M_STOP:nmode;

/* Function Name: Quantize

```

- 793 -

Engineering:KlicsCode:CompPict:KlicsEnc.c

```

/* Description:      H.261 style quantizer
 * Arguments:      new, old - image blocks
 *                pro, lev - returned values
 *                q - quantizing divisor
 * Returns:        lev is all zero, quantized data (pro) & level (lev)
 */

```

```

Boolean Quantize(int new[4], int old[4], int pro[4], int lev[4], short q)
{
    int    blk, half_q=(1<<q)-1>>1;
    for(blk=0;blk<4;blk++) {
        int    data=new[blk]-old[blk],
              mag_level=abs(data)>>q;

        mag_level=mag_level>135?135:mag_level;
        lev[blk]=negif(data<0,mag_level);
        pro[blk]=old[blk]+negif(data<0,(mag_level<<q)+(mag_level!=0?half_q:0));
    }
    return(pro[0]==0 && pro[1]==0 && pro[2]==0 && pro[3]==0);
}

```

```

void QuantizeLPF(int new[4],int pro[4],int lev[4],short q)
{
    int    blk, half_q=(1<<q)-1>>1;
    for(blk=0;blk<4;blk++) {
        int    data=new[blk],
              mag_level=abs(data)>>q;

        lev[blk]=negif(data<0,mag_level);
        pro[blk]=(lev[blk]<<q)+half_q;
    }
}

```

```

/* Function Name:  GuessQuantize
 * Description:    Estimate threshold quantiser value
 * Arguments:      new, old - image blocks
 *                q - q weighting factor
 * Returns:        estimated q_const
 */

```

```

float GuessQuantize(int new[4],int old[4],float q)
{
    int    blk;
    float  qt_max=0.0;

    for(blk=0;blk<4;blk++) {
        int    i, data=abs(new[blk]-old[blk]);
        float  qt;

        for(i=0;data!=0;i++) data>>=1;
        if (i>0) i--;
        qt=((3<<i)-1)>>1/q;

        qt_max=qt_max>qt?qt_max:qt;
    }
    return(qt_max);
}

```

```

/* Function Name:  IntEncode
 * Description:    Write a integer to bit file
 * Arguments:      lev - integer to write now signed

```

- 794 -

Engineering:KlicsCode:CompPict:KlicsEnc.c

```

    bits - no of bits
*/

void IntEncode(int lev,int bits,Buf buf)
{
    /* Old version
    int i;

    for(i=bits-1;i>=0;i--) {
        if (lev&(1<<i)) buf_set(buf);
        buf_winc(buf);
    }
    */
    /* New version
    int i, mag=abs(lev);
    Boolean sign=lev<0;

    if (1<<bits-1 <= mag) mag=(1<<bits-1)-1;
    if (sign) buf_set(buf);
    buf_winc(buf);
    for(i=1<<bits-2;i!=0;i>=1) {
        if (mag&i) buf_set(buf);
        buf_winc(buf);
    }
    */
    /* Hardware compatible version: sign mag(lsb->msb) */
    int i, mag=abs(lev);
    Boolean sign=lev<0;

    if (1<<bits-1 <= mag) mag=(1<<bits-1)-1;
    if (sign) buf_set(buf);
    buf_winc(buf);
    for(i=1;i!=1<<bits-1;i<=1) {
        if (mag&i) buf_set(buf);
        buf_winc(buf);
    }
}

/* Function Name: HuffEncodeSA
* Description: Write a Huffman coded integer to bit file
* Arguments: lev - integer value
* Returns: no of bits used
*/

void HuffEncode(int lev,Buf buf)
{
    /* int level=abs(lev);

    if (level>1) buf_set(buf);
    buf_winc(buf);
    if(level>2 || level==1) buf_set(buf);
    buf_winc(buf);
    if (level!=0) {
        if (lev<0) buf_set(buf);
        buf_winc(buf);
        if (level>2) {
            int i;

            for(i=3;i<level;i++) {
                buf_winc(buf);
            }
            buf_set(buf);
            buf_winc(buf);
        }
    }
    */
}

```

- 795 -

Engineering:KlicsCode:CompPict:KlicsEnc.c

```

    */
/* New version */
    int    level=abs(lev), i;

    if (level!=0) buf_set(buf);
    buf_winc(buf);
    if (level!=0) {
        if (lev<0) buf_set(buf);
        buf_winc(buf);
        if (level<8) {
            while (1<level--)
                buf_winc(buf);
            buf_set(buf);
            buf_winc(buf);
        } else {
            for(i=0;i<7;i++)
                buf_winc(buf);
            level-=8;
            for(i=1<=6;i!=0;i>=1) {
                if (level&i) buf_set(buf);
                buf_winc(buf);
            }
        }
    }
}

/* Function Name:  KlicsEChannel
 * Description:    Encode a channel of image
 * Arguments:      src - source channel memory
 *                 dst - destination memory (and old for videos)
 *                 octs, size - octaves of decomposition and image dimensions
 *                 normals - HVS weighted normals
 *                 lpf_bits - no of bits for LPF integer (image coding only)
 */

void KlicsEncY(short *src,short *dst,int octs,int size[2],int thresh[5], int co
{
    int    oct, mask, x, y, sub, tmp, step=2<<octs, blk[4], mode[4], nz, no, base;
    int    addr[4], new[4], old[4], pro[4], lev[4], zero[4]={0,0,0,0};
    Boolean nzflag, noflag, origin;
    int    bitmask=-1<<kle->seqh.precision-kle->frmh.quantizer[0]-1;
    Buf    buf=&kle->buf;

    for(y=0;y<size[1];y+=step)
    for(x=0;x<size[0];x+=step)
    for(sub=0;sub<4;sub++) {
        mode[oct=octs-1]=base_mode;
        if (sub==0) mode[oct=octs-1] != M_LPF;
        mask=2<<oct;
        do {
            GetAddr(addr,x,y,sub,oct,size,mask);
            switch(mode[oct]) {
                case M_VOID:
                    GetData(addr,old,dst);
                    if (BlkZero(old)) mode[oct]=M_STOP;
                    else { DoZero(addr,dst,mode,oct); }
                    break;
                case M_SEND|M_STILL:
                    GetData(addr,new,src);
                    nz=Decide(new); nzflag=nz<=thresh[octs-oct];
                    if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer[octs-oct])
                        GetData(addr,old,dst);
            }
        } while (mode[oct] != M_STOP);
    }
}

```

- 796 -

```

Engineering:KlicsCode:CompPict:KlicsEnc.c

    if (BlkZero(old)) {
        Token0;
        mode[oct]=M_STOP;
    } else {
        Token1; Token1;
        DoZero(addr,dst,mode,oct);
    }
} else {
    Token1; Token0;
    DoXfer(addr,pro,lev,dst,mode,oct,M_SEND|M_STILL,buf);
}
break;
case M_SEND:
    GetData(addr,new,src);
    GetData(addr,old,dst);
    nz=Decide(new); nzflag=nz<=thresh{octs-oct};
    if (BlkZero(old)) {
        if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer{octs-o
            Token0;
            mode[oct]=M_STOP;
        } else {
            Token1; Token0;
            DoXfer(addr,pro,lev,dst,mode,oct,M_SEND|M_STILL,buf);
        }
    } else {
        int    oz=Decide(old), no=DecideDelta(new,old);
        Boolean motion=(nz+oz)>>oct <= no; /* motion detection */

        no=DecideDelta(new,old); noflag=no<=compare{octs-oct};
        origin=nz<=no;
        if ((!noflag || motion) && !nzflag) { /* was !noflag && !nzfl
            if (Quantize(new,origin?zero:old,pro,lev,kle->frmh.quantizer{o
                Token1; Token1; Token0;
                DoZero(addr,dst,mode,oct);
            } else {
                if (origin) {
                    Token1; Token0;
                    DoXfer(addr,pro,lev,dst,mode,oct,M_SEND|M_STILL,buf);
                } else {
                    Token1; Token1; Token1;
                    DoXfer(addr,pro,lev,dst,mode,oct,M_SEND,buf);
                }
            }
        }
    } else {
        if ((motion || origin) && nzflag) { /* was origin && nzfla
            Token1; Token1; Token0;
            DoZero(addr,dst,mode,oct);
        } else {
            Token0;
            mode[oct]=M_STOP;
        }
    }
}
break;
case M_STILL:
    GetData(addr,new,src);
    nz=Decide(new); nzflag=nz<=thresh{octs-oct};
    if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer{octs-oct})
        Token0;
        mode[oct]=M_STOP;
    } else {
        Token1;
        DoXfer(addr,pro,lev,dst,mode,oct,M_STILL,buf);
    }
}

```

- 797 -

Engineering:KlicsCode:CompPict:KlicsEnc.c

```

    }
    break;
case M_LPFIM_STILL:
    GetData(addr,new,src);
    QuantizeLPF(new,pro,lev,kle->frmh.quantizer[0]);
    VerifyData(lev[0],bitmask,tmp);
    VerifyData(lev[1],bitmask,tmp);
    VerifyData(lev[2],bitmask,tmp);
    VerifyData(lev[3],bitmask,tmp);
    IntEncLev(lev,kle->seqh.precision-kle->frmh.quantizer[0],buf);
    PutData(addr,pro,dst);
    mode{oct}=M_QUIT;
    break;
case M_LPFIM_SEND:
    GetData(addr,new,src);
    GetData(addr,old,dst);
    no=DecideDelta(new,old); noflag=no<=compare{octs-oct};
    if (noflag) {
        Token0;
    } else {
        Token1;
        Quantize(new,old,pro,lev,kle->frmh.quantizer[0]);
        HuffEncLev(lev,buf);
        PutData(addr,pro,dst);
    }
    mode{oct}=M_QUIT;
    break;
}
switch(mode{oct}) {
case M_STOP:
    StopCounters(mode,oct,mask,blk,x,y,octs);
    break;
case M_QUIT:
    break;
default:
    DownCounters(mode,oct,mask,blk);
    break;
}
} while (mode{oct}!=M_QUIT);
}

void KlicsEncUV(short *src,short *dst,int octs,int size[2],int thresh[5], int c
{
    int oct, mask, x, y, X, Y, sub, tmp, step=4<<octs, blk[4], mode[4], nz, no
    int addr[4], new[4], old[4], pro[4], lev[4], zero[4]={0,0,0,0};
    Boolean nzflag, noflag, origin;
    int bitmask=-1<<kle->seqh.precision-kle->frmh.quantizer[0]-1;
    Buf buf=&kle->buf;

    for(Y=0;Y<size[1];Y+=step)
    for(X=0;X<size[0];X+=step)
    for(y=Y;y<size[1] && y<Y+step;y+=step>>1)
    for(x=X;x<size[0] && x<X+step;x+=step>>1)
    for(sub=0;sub<4;sub++) {
        mode{oct=octs-1}=base_mode;
        if (sub==0) mode{oct=octs-1} != M_LPF;
        mask=2<<oct;
        do {
            GetAddr(addr,x,y,sub,oct,size,mask);
            switch(mode{oct}) {
            case M_VOID:
                GetData(addr,old,dst);

```



- 798 -

Engineering:KlicsCode:CompPict:KlicsEnc.c

```

    if (BlkZero(old)) mode{oct}=M_STOP;
    else { DoZero(addr,dst,mode,oct); }
    break;
case M_SENDIM_STILL:
    GetData(addr,new,src);
    nz=Decide(new); nzflag=nz<=thresh{octs-oct};
    if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer{octs-oct}))
        GetData(addr,old,dst);
        if (BlkZero(old)) {
            Token0;
            mode{oct}=M_STOP;
        } else {
            Token1; Token1;
            DoZero(addr,dst,mode,oct);
        }
    } else {
        Token1; Token0;
        DoXfer(addr,pro,lev,dst,mode,oct,M_SENDIM_STILL,buf);
    }
    break;
case M_SEND:
    GetData(addr,new,src);
    GetData(addr,old,dst);
    nz=Decide(new); nzflag=nz<=thresh{octs-oct};
    if (BlkZero(old)) {
        if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer{octs-o}))
            Token0;
            mode{oct}=M_STOP;
        } else {
            Token1; Token0;
            DoXfer(addr,pro,lev,dst,mode,oct,M_SENDIM_STILL,buf);
        }
    } else {
        int oz=Decide(old), no=DecideDelta(new,old);
        Boolean motion=(nz+oz)>>oct <= no; /* motion detection */
        no=DecideDelta(new,old); noflag=no<=compare{octs-oct};
        origin=nz<=no;
        if ((!noflag || motion) && !nzflag) { /* was !noflag && !nzfl
            if (Quantize(new,origin?zero:old,pro,lev,kle->frmh.quantizer{o
                Token1; Token1; Token0;
                DoZero(addr,dst,mode,oct);
            } else {
                if (origin) {
                    Token1; Token0;
                    DoXfer(addr,pro,lev,dst,mode,oct,M_SENDIM_STILL,buf);
                } else {
                    Token1; Token1; Token1;
                    DoXfer(addr,pro,lev,dst,mode,oct,M_SEND,buf);
                }
            }
        } else {
            if ((motion || origin) && nzflag) { /* was origin && nzfla
                Token1; Token1; Token0;
                DoZero(addr,dst,mode,oct);
            } else {
                Token0;
                mode{oct}=M_STOP;
            }
        }
    }
    break;
case M_STILL:

```

- 799 -

Engineering:KlicsCode:CompPict:KlicsEnc.c

```

    GetData(addr,new,src);
    nz=Decide(new); nzflag=nz<=thresh{octs-oct};
    if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer{octs-oct});
        Token0;
        mode{oct}=M_STOP;
    } else {
        Token1;
        DoXfer(addr,pro,lev,dst,mode,oct,M_STILL,buf);
    }
    break;
case M_LPF|M_STILL:
    GetData(addr,new,src);
    QuantizeLPF(new,pro,lev,kle->frmh.quantizer[0]);
    VerifyData(lev[0],bitmask,tmp);
    VerifyData(lev[1],bitmask,tmp);
    VerifyData(lev[2],bitmask,tmp);
    VerifyData(lev[3],bitmask,tmp);
    IntEncLev(lev,kle->seqh.precision-kle->frmh.quantizer[0],buf);
    PutData(addr,pro,dst);
    mode{oct}=M_QUIT;
    break;
case M_LPF|M_SEND:
    GetData(addr,new,src);
    GetData(addr,old,dst);
    no=DecideDelta(new,old); noflag=no<=compare{octs-oct};
    if (noflag) {
        Token0;
    } else {
        Token1;
        Quantize(new,old,pro,lev,kle->frmh.quantizer[0]);
        HuffEncLev(lev,buf);
        PutData(addr,pro,dst);
    }
    mode{oct}=M_QUIT;
    break;
}
switch(mode{oct}) {
case M_STOP:
    StopCounters(mode,oct,mask,blk,x,y,octs);
    break;
case M_QUIT:
    break;
default:
    DownCounters(mode,oct,mask,blk);
    break;
}
} while (mode{oct}!=M_QUIT);
}

/* index to quant and vice versa */
#define i2q(i) (float)i*HISTO_DELTA/(float)HISTO
#define q2i(q) Fix2Long(X2Fix(q*(float)HISTO/HISTO_DELTA))

/* Function Name: LookAhead
 * Description: Examine base of tree to calculate new quantizer value
 * Arguments:  src - source channel memory
 *             dst - destination memory (and old for videos)
 *             octs, size - octaves of decomposition and image dimensions
 *             norms - base HVS weighted normals
 * Returns:    calculates new quant
 */

```

- 800 -

Engineering:KlicsCode:CompPict:KlicsEnc.c

```

void LookAhead(short *src, short *dst, float norms[5][3], KlicsE kle)
{
    int x, y, sub, index, size[2]=(kle->seqh.sequence_size[0], kle->seqh.sequence_size[1]);
    thresh[HISTO], quact[HISTO], target;
    int new[4], old[4], addr[4], zero[4]=(0,0,0,0);
    float quant;

    for(index=0; index<HISTO; index++) {
        thresh[index]=0;
        quact[index]=0;
    }
    for(y=0; y<size[1]; y+=2<<octs)
    for(x=0; x<size[0]; x+=2<<octs)
    for(sub=1; sub<4; sub++) {
        float q_thresh;
        int nz, no, oz, blk;
        Boolean ozflag, origin, motion;

        GetAddr(addr, x, y, sub, octs-1, size, 1<<octs);
        GetData(addr, new, src);
        GetData(addr, old, dst);
        nz=Decide(new);
        oz=Decide(old);
        no=DecideDelta(new, old);
        ozflag=kle->encd.intra || BlkZero(old);
        origin=nz<=no;
        motion=(nz+oz)>>octs <= no;
        q_thresh=(float)nz/DecideDouble(norms[1][1]);
        if (ozflag || origin) {
            float qt=GuessQuantize(new, zero, norms[1][0]);

            q_thresh=q_thresh<qt?q_thresh:qt;
        } else {
            float qt=GuessQuantize(new, old, norms[1][0]);

            q_thresh=q_thresh<qt?q_thresh:qt;
            if (!motion) {
                qt=(float)no/DecideDouble(norms[1][2]);
                q_thresh=q_thresh<qt?q_thresh:qt;
            }
        }
        index=q2i(q_thresh);
        index=index<0?0:index>HISTO-1?HISTO-1:index;
        thresh[index]++;
    }
    for(index=HISTO-1; index>=0; index--)
        quact[index]=thresh[index]*index+(index==HISTO-1?0:quact[index+1]);

    /* buffer must be greater than bfp_in after this frame */
    /* buffer must be less than buff_size+bfp_in */
    target=kle->encd.bpf_out*kle->encd.prevquact/kle->encd.prevbytes; /* previous
    index=1;
    while(index<HISTO && quact[index]/index>target) index++;
    quant=i2q(index);

    kle->encd.tmp_quant=(kle->encd.tmp_quant+quant)/2.0;
    kle->encd.tmp_quant=i2q((index=q2i(kle->encd.tmp_quant))); /* forward and reve
    kle->encd.prevquact=quact[index]/(index==0?1:index);
}

/* Function Name: BaseNormals

```

- 801 -

Engineering:KlicsCode:CompPict:KlicsEnc.c

```

/*
 * Description:    Calculates base HVS weighted normals
 * Arguments:    norms - storage for normals
 * Returns:      weighted normals
 */
void BaseNormals(float norms[5][3],KlicsE kle)
{
    float base_norm[3]=(1.0,kle->encd.thresh,kle->encd.compare);
    int norm, oct;

    for(oct=0;oct<5;oct++)
        for(norm=0;norm<3;norm++)
            norms[oct][norm]=base_norm[norm]*kle->encd.base[oct]*(float)(1<<kl)
}

/*
 * Function Name: Normals
 * Description:    Calculates HVS weighted normals @ quant
 * Arguments:    norms - storage for normals
 * Returns:      weighted normals and LPF bits
 */
void Normals(float base_norms[5][3],int thresh[5],int compare[5],KlicsE kle)
{
    int oct, i, norm;

    for(oct=0;oct<=kle->seqh.octaves[0];oct++) {
        norm=Fix2Long(X2Fix(base_norms[oct][0]*kle->encd.tmp_quant));
        norm=norm<1?1:norm;
        for(i=0;0!=(norm&-3);i++)
            norm=norm>>1;
        switch(norm) {
            case 1:
                kle->frmh.quantizer[oct]=i;
                break;
            case 2:
                kle->frmh.quantizer[oct]=i+1;
                break;
            case 3:
            case 4:
                kle->frmh.quantizer[oct]=i+2;
        }
        thresh[oct]=Fix2Long(X2Fix(DecideDouble(base_norms[oct][1]*kle->encd.tmp_q
        compare[oct]=Fix2Long(X2Fix(DecideDouble(base_norms[oct][2]*kle->encd.tmp_
    )
    kle->frmh.quantizer[0]=kle->frmh.quantizer[0]<3?3:kle->frmh.quantizer[0];
    /* minimum 4 bits of quant for lpf due to dynamic range problems */
}

Boolean KlicsFlags(KlicsE kle)
{
    Boolean skip=false;

    kle->encd.buffer-=kle->encd.bpf_in;
    kle->frmh.flags=0;
    if (kle->encd.buffer<0)
        kle->encd.buffer=0;
    if (kle->encd.intra)
        kle->frmh.flags |= KFH_INTRA;
    else
        if (skip=kle->encd.buf_sw && kle->encd.buffer>=kle->encd.buf_size)
            kle->frmh.flags |= KFH_SKIP;
    return(skip);
}

```

- 802 -

Engineering:KlicsCode:CompPict:KlicsEnc.c

```

,
/* Function Name: KlicsEncode
 * Description:   Encode a frame from YUV (de)transformed image
 * Arguments:    src - source image(s)
 *               dst - transformed destination memory (and old for videos)
 */
long KlicsEncode(short *src[3], short *dst[3], KlicsE kle)
{
    float base_norms[5][3];
    int    channel, thresh[5], compare[5];
    Buf    buf=&kle->buf;

    buf_winit(buf)
    if (KlicsFlags(kle))
        kle->frmh.length=0;
    else {
        for(channel=0; channel<kle->seqh.channels; channel++) {
            int size[2]=(kle->seqh.sequence_size[0]>>(channel==0?0:kle->seqh.s
                kle->seqh.sequence_size[1]>>(channel==0?0:kle->seqh.su
                area=size[0]*size[1], octs=kle->seqh.octaves[channel==0?0:

            switch(kle->seqh.wavelet) {
            case WT_Haar:
                HaarForward(src[channel], size, octs);
                break;
            case WT_Daub4:
                Daub4Forward(src[channel], size, octs);
                break;
            }
        }
        BaseNormals(base_norms, kle);
        if (kle->encd.auto_q && !kle->encd.intra)
            LookAhead(src[0], dst[0], base_norms, kle);
        else
            kle->encd.tmp_quant=kle->encd.quant;
        Normals(base_norms, thresh, compare, kle);
        for(channel=0; channel<kle->seqh.channels; channel++) {
            int size[2]=(kle->seqh.sequence_size[0]>>(channel==0?0:kle->seqh.s
                kle->seqh.sequence_size[1]>>(channel==0?0:kle->seqh.sub_sa
                octs=kle->seqh.octaves[channel==0?0:1];

            if (kle->encd.intra)
                KLZERO(dst[channel], size[0]*size[1]);
            if (channel==0) KlicsEncY(src[channel], dst[channel], octs, size, thresh, c
            else KlicsEncUV(src[channel], dst[channel], octs, size, thresh, compare, kle
        }
        buf_flush(buf);
        kle->frmh.length=buf_size(buf);
        kle->encd.buffer+=kle->frmh.length;
        if (!kle->encd.intra)
            kle->encd.prevbytes=kle->frmh.length;
    }
    return(kle->frmh.length);
}

```

- 803 -

Engineering:KlicsCode:CompPict:KlicsHeader.h

```

/*****
 *
 *  © Copyright 1993 KLICS Limited
 *  All rights reserved.
 *
 *  Written by: Adrian Lewis
 *
 *****/
/*
 *  Sequence and frame headers for Klics-Encoded files
 *  High byte first
 */

typedef struct {
    unsigned short  description_length; /* Fixed      - Size of this or parent struc
    unsigned char   version_number[2]; /* Fixed      - Version and revision numbers
} KlicsHeader;

typedef struct {
    KlicsHeader head;
    unsigned short sequence_size[3]; /* Fixed      - Size and version of this str
    unsigned char  channels;         /* Source     - Luminance dimensions and num
    unsigned char  sub_sample[2];    /* Source     - Number of channels: 3 - YUV,
    unsigned char  wavelet;          /* Source     - UV sub-sampling in X and Y d
    unsigned char  precision;        /* Source     - Wavelet used: 0 - Haar, 1 -
    unsigned char  octaves[2];       /* Source     - Bit precision for transform
    unsigned char  reserved[3];      /* Fixed      - Number of octaves Y/UV (maxi
} KlicsSeqHeader;

typedef struct {
    KlicsHeader head;
    unsigned long  length;           /* Fixed      - Size and version of this str
    unsigned long  frame_number;     /* Calc       - Length of frame data (bytes)
    unsigned char  flags;            /* Calc       - Frame number intended for se
    unsigned char  quantizer[5];     /* Calc       - Bitfield flags: 0 - frame sk
    unsigned short reserved;         /* Fixed      - Quantiser shift values{octav
} KlicsFrameHeader;

#define KFH_SKIP    0x1
#define KFH_INTRA   0x2

/*
 *  Implementation notes :
 *
 *    QuickTime    Must have KlicsFrameHeader.length set to a valid number
 *    Sun          Must have KlicsSeqHeader in data stream
 *
 *  Possible developments:
 *
 *    KlicsFrameHeader.quantizer
 *    Currently contains shift rather than step-size
 *    Different values for UV and GH,HG,GG sub-bands are not currently suppo
 */

```

- 804 -

Engineering:KlicsCode:Klics Codec:KlicsEncode.r

```

/*
 * KlicsEncode resource file
 */

#include "Types.r"
#include "MPWTypes.r"
#include "ImageCodec.r"

/*
 * Klics Compressor included into the applications resource file here
 */

#define klicsCodecFormatName    "Klics"
#define klicsCodecFormatType    'klic'

/*
 * This structure defines the capabilities of the codec. There will
 * probably be a tool for creating this resource, which measures the performance
 * and capabilities of your codec.
 */
resource 'cdci' (129, "Klics CodecInfo", locked) {
    klicsCodecFormatName, /* name of the codec TYPE ( da
    1, /* version */
    1, /* revision */
    'klic', /* who made this codec */
    0,
    codecInfoDoes32|codecInfoDoes8|codecInfoDoesTemporal, /* depth and etc suppo
    codecInfoDepth24|codecInfoSequenceSensitive, /* which data formats do we un
    100, /* compress accuracy (0-255) (
    100, /* decompress accuracy (0-255)
    0, /* millisecs to compress 320x2
    0, /* millisecs to decompress 320
    0, /* compression level (0-255) (
    32,
    32, /* minimum height */
    0, /* minimum width */
    0,
    0
};

resource 'thng' (128, "Klics Compressor", locked) {
    compressorComponentType,
    klicsCodecFormatType,
    'klic',
    codecInfoDoes32|codecInfoDoes8|codecInfoDoesTemporal,
    0,
    'cdec',
    128,
    'STR ',
    128,
    'STR ',
    129,
    'ICON',
    128
};

resource 'STR ' (128) {
    "Klics Compress"

```

- 805 -

```
Engineering:KlicsCode:Klics Codec:KlicsEncoda.r  
);  
resource 'STR' (129) {  
    "Wavelet transform & multiresolution tree based coding scheme"  
};
```



- 806 -

Engineering:KlicsCode:Klics Codec:KlicsDecode.r

```

/*
 * KlicsDecode resource file
 */

#include "Types.r"
#include "MPWTypes.r"
#include "ImageCodec.r"

/*
 * Klics Compressor included into the applications resource file here.
 */

#define klicsCodecFormatName    'Klics'
#define klicsCodecFormatType    'klic'

/*

This structure defines the capabilities of the codec. There will
probably be a tool for creating this resource, which measures the performance
and capabilities of your codec.

*/
resource 'cdci' (129, 'Klics CodecInfo', locked) {
    klicsCodecFormatName,          /* name of the codec TYPE ( da
    1,                             /* version */
    1,                             /* revision */
    'klic',                       /* who made this codec */
    codecInfoDoes32|codecInfoDoes16|codecInfoDoes8|codecInfoDoesTemporal|codecInfo
    0,
    codecInfoDepth24|codecInfoSequenceSensitive, /* which data formats do we un
    100,                             /* compress accuracy (0-255) (
    100,                             /* decompress accuracy (0-255)
    0,                             /* millisecs to compress 320x2
    0,                             /* millisecs to decompress 320
    0,                             /* compression level (0-255) (
    0,
    32,                             /* minimum height */
    32,                             /* minimum width */
    0,
    0,
    0
};

resource 'thng' (130, 'Klics Decompressor', locked) {
    decompressorComponentType,
    klicsCodecFormatType,
    'klic',
    codecInfoDoes32|codecInfoDoes16|codecInfoDoes8|codecInfoDoesTemporal|codecInfo
    0,
    'cdec',
    128,
    'STR ',
    130,
    'STR ',
    131,
    'ICON',
    130
};

resource 'STR ' (130) {

```

- 807 -

CLAIMS

WE CLAIM:

1. A method of transforming a sequence of input digital data values into a first sequence of transformed digital data values and of inverse transforming a second sequence of transformed digital data values into a sequence of output digital data values, said sequence of input digital data values comprising a boundary subsequence and a non-boundary subsequence, comprising the steps of:
  - 10 running a number of said input digital data values of said boundary subsequence through a low pass boundary forward transform perfect reconstruction digital filter and through a high pass boundary forward transform perfect reconstruction digital filter to produce a first subsequence of said first sequence of transformed digital data values, said first subsequence of said first sequence of transformed digital data values comprising interleaved low and high frequency transformed digital data values;
  - 20 running a number of said input digital data values of said non-boundary subsequence through a low pass non-boundary forward transform perfect reconstruction digital filter and also through a high pass non-boundary forward transform perfect reconstruction digital filter to produce a second subsequence of said first sequence of transformed digital data values, said second subsequence of said first sequence of transformed digital data values comprising interleaved low and high frequency transformed digital data values, said low pass boundary forward transform perfect reconstruction digital filter having a fewer number of coefficients than said low pass non-boundary forward transform perfect reconstruction digital filter, said high pass boundary forward transform perfect reconstruction digital filter having a fewer number of coefficients
  - 25
  - 30
  - 35

- 808 -

than said high pass non-boundary forward transform perfect reconstruction digital filter;

converting said first sequence of transformed digital data values into said second sequence of transformed digital data values, said second sequence of transformed digital data values comprising a first subsequence of said second sequence of transformed digital data values and a second subsequence of said second sequence of transformed digital data values;

running a number of said first subsequence of said second sequence of transformed digital data values through an interleaved boundary inverse transform perfect reconstruction digital filter to produce at least one output digital data value;

running a number of said second subsequence of said second sequence of transformed digital data values through a first interleaved non-boundary inverse transform perfect reconstruction digital filter to produce output digital data values; and

running a number of said second subsequence of transformed digital data values through a second interleaved non-boundary inverse transform perfect reconstruction digital filter to produce output digital data values, said output digital data values produced by said interleaved boundary inverse transform perfect reconstruction digital filter, said first interleaved non-boundary inverse transform perfect reconstruction digital filter, and said second interleaved non-boundary inverse transform perfect reconstruction digital filter comprising a subsequence of said output digital data values of said sequence of output digital data values.

2. The method of Claim 1, wherein said low pass boundary forward transform perfect reconstruction digital filter has X coefficients and wherein said low pass non-boundary forward transform perfect reconstruction digital

- 809 -

filter has  $Y$  coefficients,  $Y$  being greater than  $X$ , said  $X$  coefficients of said low pass boundary forward transform perfect reconstruction digital filter being chosen so that said low pass boundary forward transform perfect  
5 reconstruction digital filter outputs a transformed digital data value  $H_0$  when the low pass boundary forward perfect transform reconstruction digital filter operates on input digital data values  $ID_0-ID_{X-1}$  adjacent said boundary, said transformed digital data value  $H_0$  being substantially equal  
10 to what the output of the low pass non-boundary forward transform perfect reconstruction digital filter would be were the low pass non-boundary forward perfect reconstruction digital filter to operate on  $ID_0-ID_{X-1}$  as well as  $Y-X$  additional input digital data values outside  
15 said boundary, said additional input digital data values having preselected values.

3. The method of Claim 2, wherein  $Y-X=1$ , wherein there is one additional input digital data value  $ID_{-1}$ , and wherein  $ID_{-1}$  is preselected to be substantially equal to  
20  $ID_0$ .

4. The method of Claim 2, wherein  $Y-X=1$ , wherein there is one additional input digital data value  $ID_{-1}$ , and wherein  $ID_{-1}$  is preselected to be substantially equal to zero.

25 5. The method of Claim 1, wherein said sequence of input digital data values is a sequence of digital data values associated with pixels of either a row or a column of a two dimensional image, said boundary of said sequence of input digital data values corresponding with either a  
30 start or an end of said row or said column.

6. The method of Claim 1, wherein said sequence of input digital data values is a sequence of digital data values associated with an audio signal.

- 810 -

7. The method of Claim 1, wherein said low and high pass non-boundary forward transform perfect reconstruction digital filters are forward transform quasi-perfect reconstruction filters which have coefficients which  
 5 approximate the coefficients of true forward transform perfect reconstruction filters.

8. The method of Claim 1, wherein said low and high pass non-boundary forward transform perfect reconstruction digital filters are both four coefficient quasi-Daubechies  
 10 filters the coefficients of which approximate the coefficients of true four coefficient Daubechies filters.

9. The method of Claim 8, wherein one of said four coefficient quasi-Daubechies filters has the coefficients 11/32, 19/32, 5/32 and 3/32 independent of sign.

15 10. The method of Claim 1, wherein said low pass non-boundary forward transform perfect reconstruction digital filter is a four coefficient quasi-Daubechies filter H of the form:

$$H_n = aID_{2n-1} + bID_{2n} + cID_{2n+1} - dID_{2n+2}$$

20 n being a positive integer,  $ID_0$ - $ID_m$  being input digital data values, m being a positive integer,  $ID_0$  being the first input digital data value in said sequence of input digital data values, and wherein said low pass boundary forward transform perfect reconstruction digital filter is a three  
 25 coefficient digital filter of the form:

$$H_0 = aID_{-1} + bID_0 + cID_1 - dID_2$$

$ID_{-1}$  being a predetermined input digital data value outside said boundary and having a preselected value.

11. The method of Claim 10, wherein said high pass

- 811 -

non-boundary forward transform perfect reconstruction digital filter is a four coefficient quasi-Daubechies filter of the form:

$$G_n = dID_{2n-1} + cID_{2n} - bID_{2n+1} + aID_{2n+2}$$

5 n being a positive integer, and wherein said high pass boundary forward transform perfect reconstruction digital filter is a three coefficient digital filter of the form:

$$G_0 = dID_{-1} + cID_0 - bID_1 + aID_2$$

dID<sub>-1</sub> having a preselected value.

10 12. The method of Claim 11, wherein:  $a + b + c - d$  is substantially equal to 1, wherein  $a - b + c + d$  is substantially equal to 0, and wherein  $ac - bd$  is substantially equal to zero.

13. The method of Claim 12, wherein:  $a=11/32$ ,  
15  $b=19/32$ ,  $c=5/32$  and  $d=3/32$ .

14. The method of Claim 11, wherein said interleaved boundary inverse transform perfect reconstruction digital filter is a two coefficient digital filter of the form:

$$OD_0 = 4(b-a)H_0 + 4(c-d)G_0$$

20 wherein  $OD_0$  is an output digital data value of said sequence of output digital data values, wherein  $G_0$  is the output of said high pass boundary forward transform perfect reconstruction digital filter when the high pass boundary forward transform perfect reconstruction digital  
25 filter operates on input digital data values  $ID_0$ ,  $ID_1$  and  $ID_2$  adjacent said boundary, and wherein  $H_0$  is the output of said low pass boundary forward transform perfect reconstruction digital filter when the low pass boundary

- 812 -

forward transform perfect reconstruction digital filter operates on input digital data values  $ID_0$ ,  $ID_1$  and  $ID_2$  adjacent said boundary.

15. The method of Claim 14, wherein one of said first  
5 and second interleaved non-boundary inverse transform perfect reconstruction digital filters is of the form:

$$D_{2n+1} = 2(cH_n - bG_n + aH_{n+1} + dG_{n+1})$$

$n$  being a non-negative integer, and wherein the other of  
said first and second interleaved non-boundary inverse  
10 perfect reconstruction digital filters is of the form:

$$D_{2n+2} = 2(-dH_n + aG_n + bH_{n+1} + cG_{n+1})$$

$n$  being a non-negative integer, wherein  $H_n$ ,  $G_n$ ,  $H_{n+1}$  and  $G_{n+1}$   
comprise a subsequence of said second sequence of  
transformed digital data values.

15 16. The method of Claim 1, wherein said low pass non-boundary forward transform perfect reconstruction digital filter is a four coefficient quasi-Daubechies filter having the coefficients:  $11/32$ ,  $19/32$ ,  $5/32$  and  $-3/32$ , and wherein  
20 said high pass non-boundary forward transform perfect reconstruction digital filter is a four coefficient quasi-Daubechies filter having the coefficients:  $3/32$ ,  $5/32$ ,  $-19/32$  and  $11/32$ .

17. The method of Claim 1, wherein said low and high  
pass non-boundary forward transform perfect reconstruction  
25 digital filters are chosen from the group consisting of:  
true six coefficient Daubechies filters and quasi-Daubechies filters, the coefficients of the quasi-Daubechies filters approximating the coefficients of true six coefficient Daubechies filters.

- 813 -

18. The method of Claim 1, further comprising the steps of:

encoding said first sequence of transformed  
digital data values into an encoded sequence; and  
5 decoding said encoded sequence of digital data  
values into said second sequence of transformed  
digital data values and supplying said second sequence  
of transformed digital data values to said interleaved  
boundary inverse transform perfect reconstruction  
10 digital filter, said first interleaved non-boundary  
inverse transform perfect reconstruction digital  
filter, and said second interleaved non-boundary  
inverse transform perfect reconstruction digital  
filter.

15 19. The method of Claim 18, further comprising the  
step of:

quantizing each of said digital data values in  
said first sequence of transformed values before said  
encoding step.

20 20. The method of Claim 1, wherein each of said input  
digital data values of said sequence of input digital data  
values is stored in a separate memory location, and wherein  
some of said memory locations are overwritten in a sequence  
with said sequence of transformed digital data values as  
25 said digital data input values are transformed into said  
transformed digital data values.

21. A method of transforming a sequence of input  
digital data values into a sequence of transformed digital  
data values, said sequence of input digital data values  
30 comprising a boundary subsequence and a non-boundary  
subsequence, comprising the steps of:

running a number of said input digital data  
values of said boundary subsequence through a low pass  
boundary forward transform perfect reconstruction



- 814 -

digital filter and through a high pass boundary  
forward transform perfect reconstruction digital  
filter to produce a first subsequence of said sequence  
of transformed digital data values, said first  
5 subsequence of said sequence of transformed digital  
data values comprising interleaved low and high  
frequency transformed digital data values; and  
running a number of said input digital data  
values of said non-boundary subsequence through a low  
10 pass non-boundary forward transform perfect  
reconstruction digital filter and also through a high  
pass non-boundary forward transform perfect  
reconstruction digital filter to produce a second  
subsequence of said sequence of transformed digital  
15 data values, said second subsequence of said sequence  
of transformed digital data values comprising  
interleaved low and high frequency transformed digital  
data values, said low pass boundary forward transform  
perfect reconstruction digital filter having a fewer  
20 number of coefficients than said low pass non-boundary  
forward transform perfect reconstruction digital  
filter, said high pass boundary forward transform  
perfect reconstruction digital filter having a fewer  
number of coefficients than said high pass non-  
25 boundary forward transform perfect reconstruction  
digital filter.

22. A method, comprising the steps of:  
generating a sub-band decomposition having a  
plurality of octaves, a first of said plurality of  
30 octaves comprising at least one first digital data  
value, a second of said plurality of octaves  
comprising at least one second digital data value;  
calculating a sum of the absolute values of said  
at least one first digital data value;  
35 determining if said at least one first digital  
data value is interesting using a first threshold

- 815 -

limit;

calculating a sum of the absolute values of said  
at least one second digital data value; and

5 determining if said at least one second digital  
data value is interesting using a second threshold  
limit.

23. A method of traversing a tree decomposition, said  
tree decomposition comprising a plurality of transformed  
data values, each of said plurality of transformed data  
10 values having a unique address identified by coordinates X  
and Y, comprising the step of:

calculating at least four transformed data value  
addresses by incrementing a count, the count  
comprising one bit  $C1_x$  in the X coordinate and one bit  
15  $C1_y$  in the Y coordinate, to generate said at least  
four transformed data value addresses.

24. A method, comprising the step of:

determining an address of a transformed data value in  
a tree decomposition by shifting a value a number of times,  
20 said tree decomposition having a number of octaves, said  
transformed data value being in one of said octaves, said  
number of times being at least dependent upon said one  
octave.

25. A method, comprising the step of:

25 determining an address of a transformed data value in  
a tree decomposition by multiplying a value by a factor,  
said tree decomposition having a number of octaves, said  
transformed data value being in one of said octaves, said  
factor being at least dependent upon said one octave.

30 26. A method, comprising the step of:

determining an address of a transformed data value in  
a tree decomposition by shifting a value a number of times,  
said tree decomposition having a number of frequency sub-

- 816 -

bands, said transformed data value being in one of said frequency sub-bands, said number of times being at least dependent upon said frequency sub-band.

27. A method, comprising the step of:

5 determining an address of a transformed data value in a tree decomposition by performing a logical operation upon a value, said tree decomposition having a number of frequency sub-bands, said transformed data value being in one of said frequency sub-bands, said logical operation  
10 performed being at least dependent upon said one frequency sub-band.

28. The method of Claim 27, wherein said logical operation is a bit-wise logical AND operation.

29. A method for determining a low pass quasi-perfect  
15 reconstruction filter and a high pass quasi-perfect reconstruction filter from a wavelet function, said low pass quasi-perfect reconstruction filter having a plurality of coefficients, said high pass quasi-perfect reconstruction filter having a plurality of coefficients,  
20 comprising the steps of:

determining a low pass wavelet digital filter and a high pass wavelet digital filter from said wavelet function, said low pass wavelet digital filter having a plurality of coefficients, said high pass wavelet digital  
25 filter having a plurality of coefficients;

choosing the coefficients of said low pass quasi-perfect reconstruction digital filter to be fractions such that when a sequence of data values having values of 1 is processed by said low pass quasi-perfect reconstruction  
30 digital filter the output of said low pass quasi-perfect reconstruction digital filter is exactly a power of 2; and

choosing the coefficients of the high pass quasi-perfect reconstruction digital filter to be fractions such that when a sequence of data values having values of 1 is

- 817 -

processed by said high pass quasi-perfect reconstruction digital filter the output of said high pass quasi-perfect reconstruction digital filter is exactly 0, whereby each of the plurality of coefficients of said low pass quasi-  
5 perfect reconstruction digital filter is substantially identical to a corresponding one of said plurality of coefficients of said low pass wavelet digital filter, and whereby each of the plurality of coefficients of said high pass quasi-perfect reconstruction digital filter is  
10 substantially identical to a corresponding one of said plurality of coefficients of said high pass wavelet digital filter.

30. A method of estimating a compression ratio of a number of original data values to a number of compressed  
15 data values at a value of a quality factor Q, comprising the steps of:

examining a first block of transformed data values of a tree, said first block being one of a number of lowest frequency blocks of a high pass component sub-band, said  
20 tree being part of a sub-band decomposition; and

determining a value of said quality factor Q at which said data values of said first block would be converted into compressed data values, and not determining a value of said quality factor Q at which any other block of data  
25 values of said tree would be converted into a number of compressed data values.

31. The method of Claim 30, wherein said number of original data values represents a frame of an image.

32. The method of Claim 31, further comprising the  
30 step of:

determining a number of lowest frequency blocks of said high pass component sub-band which would be converted into compressed data values given a value of said quality factor Q.

- 818 -

33. A method of transforming a sequence of image data values, comprising the step of:

filtering said sequence of image data values using a quasi-perfect reconstruction filter to generate a  
5 decomposition having a plurality of octaves, said quasi-perfect reconstruction filter having six coefficients.

34. The method of Claim 33, wherein said six coefficients are selected from the group consisting of:  
30/128, 73/128, 41/128, 12/128, 7/128 and 3/128,  
10 irrespective of sign.

35. A method of detecting motion in a tree decomposition, said tree decomposition comprising a plurality of octaves of blocks of data values, comprising the steps of:

15 comparing data values of a first block in an octave with data values of a second block in said octave; and  
generating a token indicating motion based on said comparing.

36. A method, comprising the steps of:  
20 generating a sub-band decomposition having a plurality of octaves, a first of said plurality of octaves comprising at least one first digital data value, a second of said plurality of octaves comprising at least one second digital data value;  
25 determining if said at least one first digital data value is interesting using a first threshold limit; and  
determining if said at least one second digital data value is interesting using a second threshold limit.

37. A method, comprising the steps of:  
30 generating a sub-band decomposition of a first frame having a plurality of octaves, a first of said plurality of octaves comprising at least one first digital data value, a

- 819 -

second of said plurality of octaves comprising at least one second digital data value;

generating a sub-band decomposition of a second frame having a plurality of octaves, a first of said plurality of 5 octaves comprising at least one first digital data value, a second of said plurality of octaves comprising at least one second digital data value;

comparing said first digital data value of said first frame with said first digital data value of said second 10 frame using a first threshold compare; and

comparing said second digital data value of said first frame with said second digital data value of said second frame using a second threshold compare.

38. A method, comprising the steps of:

15 reading a sequence of data values from a plurality of memory locations, each of said data values being stored in a separate one of said plurality of memory locations; and  
overwriting some of said memory locations in a sequence as said data values are transformed into a  
20 sequence of transformed data values of a sub-band decomposition.

39. A method, comprising the steps of:

performing a function on a plurality of data values of a new block to generate a first output value, said new 25 block being a block of data values of a sub-band decomposition of a new frame;

performing said function on a plurality of numbers to generate a second output value, each of said numbers substantially equalling a difference of a data value in  
30 said plurality of data values of said new block and a corresponding data value in a corresponding plurality of data values of an old block, said old block being a block of data values of a sub-band decomposition of an old frame; and

35 generating a token if said first output value has a

- 820 -

predetermined relationship with respect to said second output value.

40. The method of Claim 39, wherein said token is a SEND\_STILL token.

5 41. A method, comprising the steps of:

performing a function on a plurality of data values of a new block to generate a corresponding plurality of output values, said new block being a block of data values of a sub-band decomposition;

10 comparing each of said plurality of output values with a predetermined number; and

generating a token if substantially all of said output values have a predetermined relationship with respect to said predetermined number.

15 42. The method of Claim 41, wherein said token is a VOID token.

43. A method, comprising the steps of:

subtracting each one of a plurality of data values of a new block with a corresponding one of a plurality of data values of a old block to generate a corresponding plurality of output values, said new block being a block of data values of a sub-band decomposition of a new frame, said old block being a block of data values of a sub-band decomposition of a old frame;

25 comparing each of said plurality of output values with a predetermined number; and

generating a token if substantially all of said output values have a predetermined relationship with respect to said predetermined number.

30 44. The method of Claim 43, wherein said token is a VOID token.

- 821 -

45. A method, comprising the steps of:  
determining an absolute value for each of a plurality  
of data values of a block of a sub-band decomposition;  
determining a sum of said absolute values; and  
5 generating a token based on a comparison of said sum  
with a predetermined number.

46. The method of Claim 45, wherein said token is a  
VOID token.

47. A method, comprising the steps of:  
10 processing a sequence of first image data values using  
a low pass forward transform perfect reconstruction digital  
filter and a high pass forward transform perfect  
reconstruction digital filter to create a first sequence of  
transformed data values, said low pass forward transform  
15 perfect reconstruction digital filter and said high pass  
forward transform perfect reconstruction digital filter  
each having coefficients chosen from a first group of  
coefficients independent of sign;  
converting said first sequence of transformed data  
20 values into a second sequence of transformed data values;  
and  
using digital circuitry to process said second  
sequence of transformed data values using a low pass  
inverse transform perfect reconstruction digital filter and  
25 a high pass inverse transform perfect reconstruction  
digital filter into a sequence of second image data values,  
said low pass inverse transform perfect reconstruction  
digital filter and said high pass inverse transform perfect  
reconstruction digital filter each having coefficients  
30 chosen from a second group of coefficients independent of  
sign.

48. The method of claim 47, wherein said digital  
circuitry used to process said second sequence of  
transformed data values is a digital computer having a



- 822 -

microprocessor.

49. The method of claim 47, wherein at least one of the coefficients in said first group of coefficients is not contained in said second group of coefficients.

5 50. The method of claim 47, wherein said first group of coefficients has a different number of coefficients than said second group of coefficients.

51. The method of claim 50, wherein said sequence of first image data values is a sequence of chrominance data  
10 values.

52. The method of claim 50, wherein said low pass forward transform perfect reconstruction digital filter and said high pass forward transform perfect reconstruction digital filter each have four coefficients, and wherein  
15 said low pass inverse transform perfect reconstruction digital filter and said high pass inverse transform perfect reconstruction digital filter each have two coefficients.

53. The method of claim 52, wherein said sequence of first image data values is a sequence of chrominance data  
20 values.

54. The method of claim 47, wherein each of said coefficients of said low pass inverse transform perfect reconstruction digital filter and said high pass inverse transform perfect reconstruction digital filter is selected  
25 from the group consisting of:  $5/8$ ,  $3/8$  and  $1/8$ , independent of sign.

55. The method of claim 47, wherein said converting step comprises the steps of:

encoding said first sequence of transformed data  
30 values into a compressed data stream; and

- 823 -

decoding said compressed data stream into said second sequence of transformed data values.

56. A method comprising the step of using digital circuitry to process a sequence of image data values using  
5 a low pass forward transform perfect reconstruction digital filter and a high pass forward transform perfect reconstruction digital filter to generate a sub-band decomposition, said low pass forward transform perfect reconstruction digital filter and said high pass forward  
10 transform perfect reconstruction digital filter each having four coefficients, each of said four coefficients being selected from the group consisting of:  $5/8$ ,  $3/8$  and  $1/8$ , independent of sign.

57. The method of claim 56, wherein said digital  
15 circuitry comprises means for low pass forward transform perfect reconstruction digital filtering and for high pass forward transform perfect reconstruction digital filtering.

58. A method comprising the step of using digital circuitry to process a sequence of transformed data values  
20 of a sub-band decomposition using an odd inverse transform perfect reconstruction digital filter and an even inverse transform perfect reconstruction digital filter, said odd inverse transform perfect reconstruction digital filter and said even inverse transform perfect reconstruction digital  
25 filter each having four coefficients, each of said four coefficients being selected from the group consisting of:  $5/8$ ,  $3/8$  and  $1/8$ , independent of sign.

59. The method of claim 58, wherein said digital circuitry is a digital computer having a microprocessor.

30 60. A method comprising the step of generating a compressed data stream indicative of a video sequence from a sub-band decomposition, said compressed data stream

- 824 -

comprising a first data value, a first token, a second data value, and a second token, said first token being indicative of a first encoding method used to encode said first data value, said second token being indicative of a second encoding method used to encode said second data value, said first token consisting of a first number of bits and said second token consisting of a second number of bits.

61. The method of claim 60, wherein said first encoding method is taken from the group consisting of: SEND mode, STILL\_SEND mode, VOID mode, and STOP mode.

62. The method of claim 60, wherein said first token is a single bit token.

63. A method, comprising the steps of:

15 forward transforming image data values to generate a first sequence of transformed data values of a first sub-band decomposition, said first sub-band decomposing having a first number of octaves;

converting said first sequence of transformed data values into a second sequence of transformed data values;

20 using digital circuitry to inverse transforming said second sequence of transformed data values into a third sequence of transformed data values, said third sequence of transformed data values comprising a second sub-band decomposition having a second number of octaves, said second number of octaves being smaller than said first number of octaves, said second sub-band decomposition having a low pass component, said low pass component of said second sub-band decomposition comprising data values

25 indicative of rows of data values of an image, said rows of said image extending in a first dimension, said image also having columns of said data values extending in a second dimension;

expanding said low pass component in said first

30

- 825 -

dimension using interpolation to generate an interpolated low pass component; and

expanding said interpolated low pass component in said second dimension by replicating rows of said data values of 5 said interpolated low pass component.

64. The method of claim 63, wherein said digital circuitry is a digital computer having a microprocessor.

65. The method of claim 63, wherein said converting step comprises the steps of:

10 encoding said first sequence of transformed data values into a compressed data stream comprising tokens and encoded data values; and

decoding said compressed data stream into said second sequence of transformed data values.

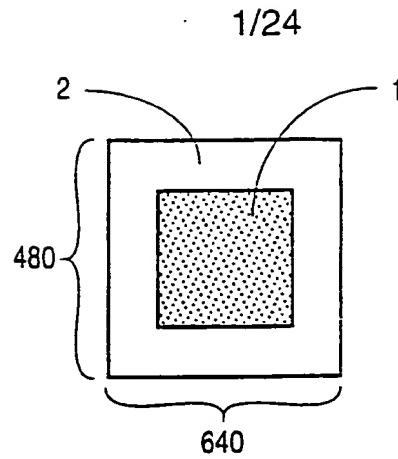


Fig. 1  
(PRIOR ART)

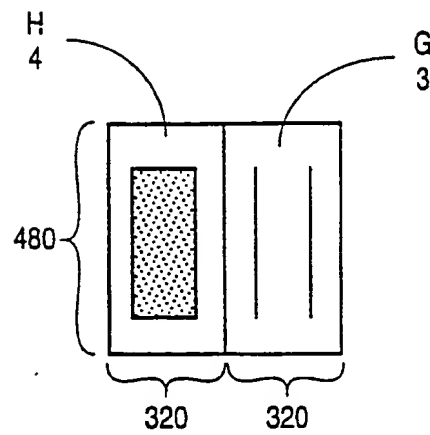


Fig. 2  
(PRIOR ART)

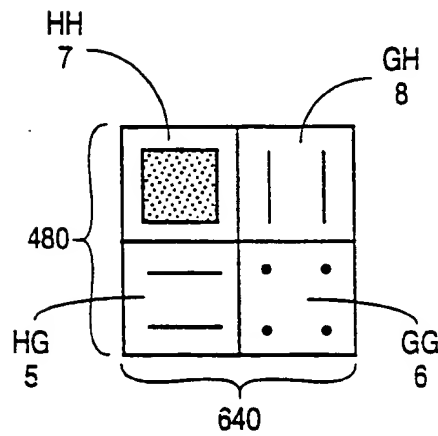


Fig. 3  
(PRIOR ART)

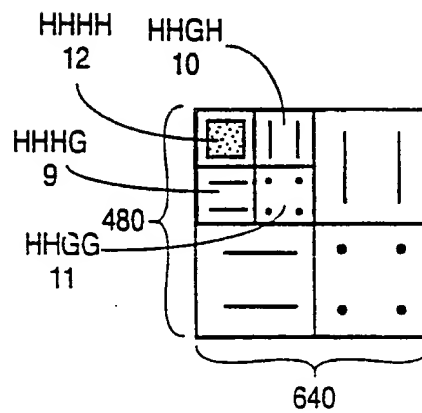


Fig. 4  
(PRIOR ART)

2/24

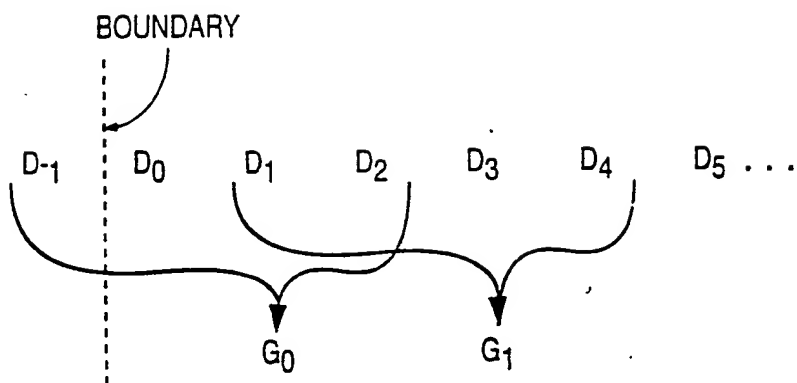


Fig. 5  
(PRIOR ART)

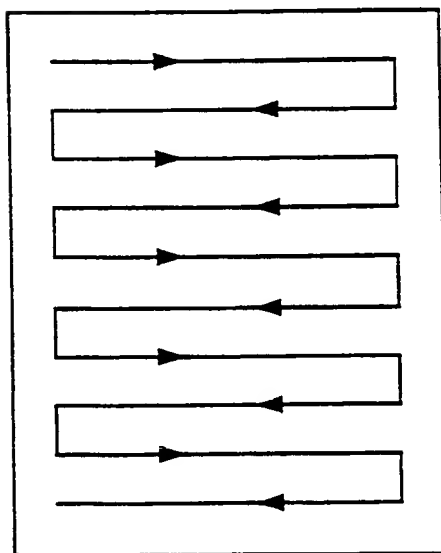


Fig. 6  
(PRIOR ART)

3/24

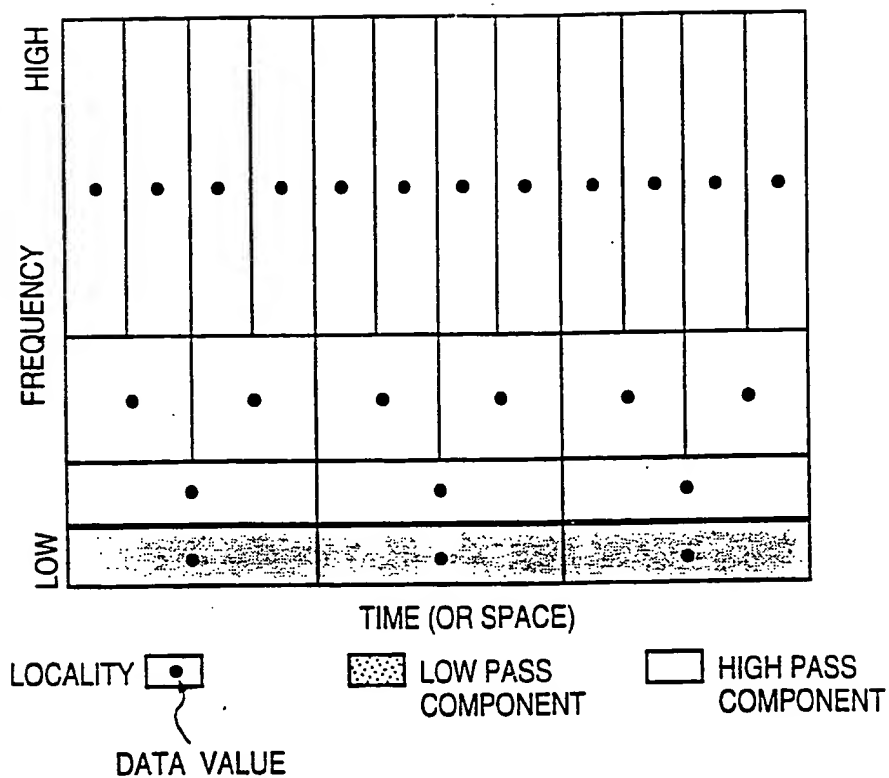


Fig. 7

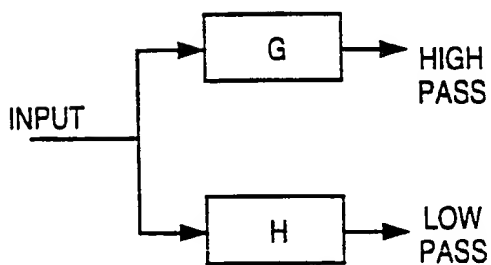


Fig. 8

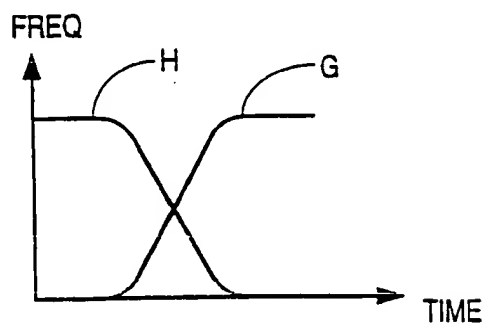


Fig. 9

4/24

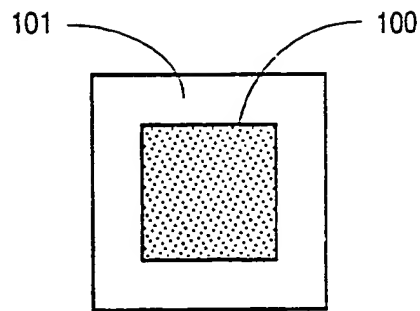


Fig. 10

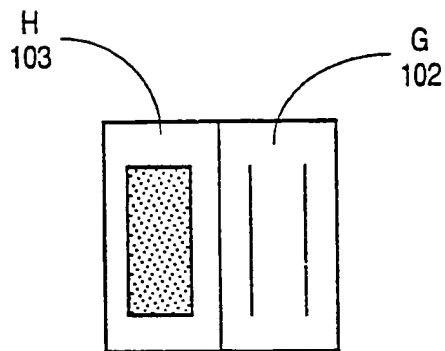


Fig. 11

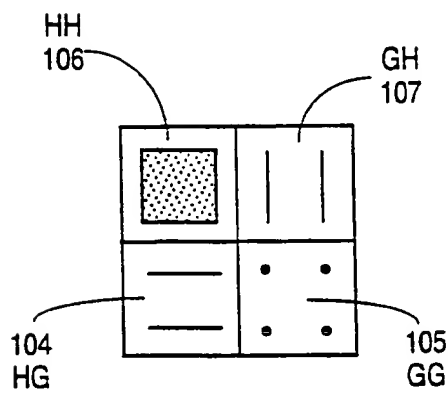


Fig. 14

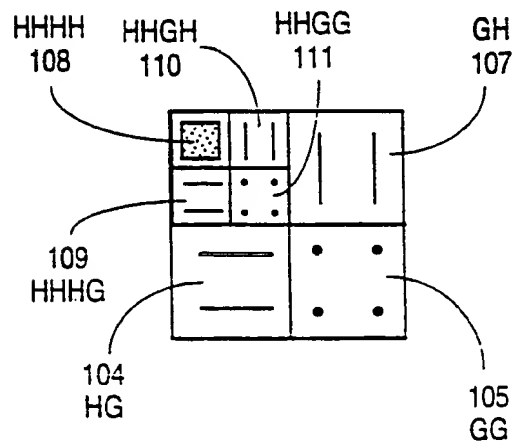


Fig. 15



5/24

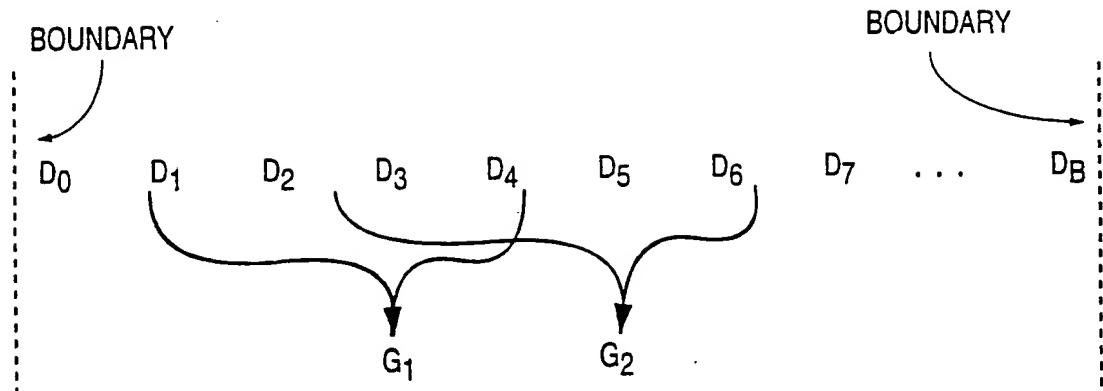


Fig. 12

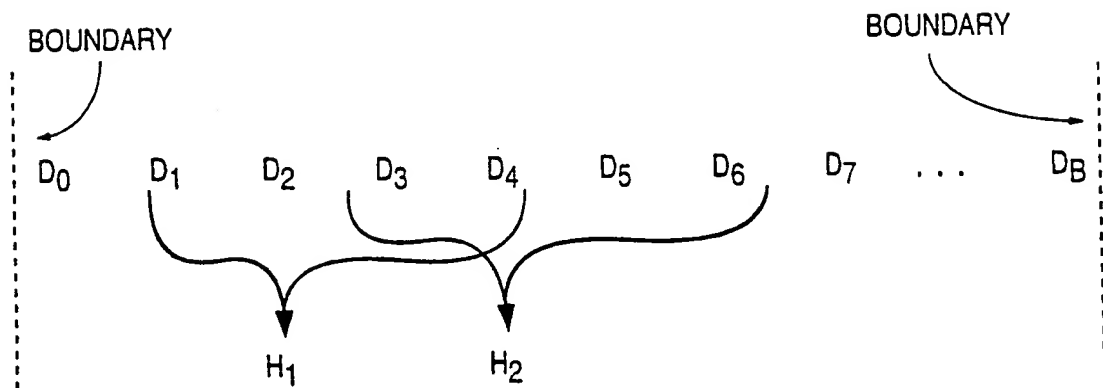


Fig. 13

6/24

		COLUMN												
	0	1	2	3	4	5	6	7	8	9	A	B		
0	D00	D01	D02	D03	D04	D05	D06	D07	D08	D09	D0A	D0B		
1	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19	D1A	D1B		
2	D20	D21	D22	D23	D24	D25	D26	D27	D28	D29	D2A	D2B		
3	D30	D31	D32	D33	D34	D35	D36	D37	D38	D39	D3A	D3B		
4	D40	D41	D42	D43	D44	D45	D46	D47	D48	D49	D4A	D4B		
5	D50	D51	D52	D53	D54	D55	D56	D57	D58	D59	D5A	D5B		
6	D60	D61	D63	D63	D64	D65	D66	D67	D68	D69	D6A	D6B		
7	D70	D71	D72	D73	D74	D75	D76	D77	D78	D79	D7A	D7B		
8	D80	D81	D82	D83	D84	D85	D86	D87	D88	D89	D8A	D8B		
9	D90	D91	D92	D93	D94	D95	D96	D97	D98	D99	D9A	D9B		
A	DA0	DA1	DA2	DA3	DA4	DA5	DA6	DA7	DA8	DA9	DAA	DAB		
B	DB0	DB1	DB2	DB3	DB4	DB5	DB6	DB7	DB8	DB9	DBA	DBB		

R  
O  
W

Fig. 16

7/24

	COLUMN											
	0	1	2	3	4	5	6	7	8	9	A	B
0	HH00	GH00	HH01	GH01	HH02	GH02	HH03	GH03	HH04	GH04	HH05	GH05
1	HG00	GG00	HG01	GG01	HG02	GG02	HG03	GG03	HG04	GG04	HG05	GG05
2	HH10	GH10	HH11	GH11	HH12	GH12	HH13	GH13	HH14	GH14	HH15	GH15
3	HG10	GG10	HG11	GG11	HG12	GG12	HG13	GG13	HG14	GG14	HG15	GG15
4	HH20	GH20	HH21	GH21	HH22	GH22	HH23	GH23	HH24	GH24	HH25	GH25
5	HG20	GG20	HG21	GG21	HG22	GG22	HG23	GG23	HG24	GG24	HG25	GG25
6	HH30	GH30	HH31	GH31	HH32	GH32	HH33	GH33	HH34	GH34	HH35	GH35
7	HG30	GG30	HG31	GG31	HG32	GG32	HG33	GG33	HG34	GG34	HG35	GG35
8	HH40	GH40	HH41	GH41	HH42	GH42	HH43	GH43	HH44	GH44	HH45	GH45
9	HG40	GG40	HG41	GG41	HG42	GG42	HG43	GG43	HG44	GG44	HG45	GG45
A	HH50	GH50	HH51	GH51	HH52	GH52	HH53	GH53	HH54	GH54	HH55	GH55
B	HG50	GG50	HG51	GG51	HG52	GG52	HG53	GG53	HG54	GG54	HG55	GG55

Fig. 17

8/24

COLUMN												
	0	1	2	3	4	5	6	7	8	9	A	B
0	HHHH <sub>00</sub>	GH <sub>00</sub>	HHGH <sub>00</sub>	GH <sub>01</sub>	HHHH <sub>01</sub>	GH <sub>02</sub>	HHGH <sub>01</sub>	GH <sub>03</sub>	HHHH <sub>02</sub>	GH <sub>04</sub>	HHGH <sub>02</sub>	GH <sub>05</sub>
1	HG <sub>00</sub>	GG <sub>00</sub>	HG <sub>01</sub>	GG <sub>01</sub>	HG <sub>02</sub>	GG <sub>02</sub>	HG <sub>03</sub>	GG <sub>03</sub>	HG <sub>04</sub>	GG <sub>04</sub>	HG <sub>05</sub>	GG <sub>05</sub>
2	HHHG <sub>00</sub>	GH <sub>10</sub>	HHGG <sub>00</sub>	GH <sub>11</sub>	HHHG <sub>01</sub>	GH <sub>12</sub>	HHGG <sub>01</sub>	GH <sub>13</sub>	HHHG <sub>02</sub>	GH <sub>14</sub>	HHGG <sub>02</sub>	GH <sub>15</sub>
3	HG <sub>10</sub>	GG <sub>10</sub>	HG <sub>11</sub>	GG <sub>11</sub>	HG <sub>12</sub>	GG <sub>12</sub>	HG <sub>13</sub>	GG <sub>13</sub>	HG <sub>14</sub>	GG <sub>14</sub>	HG <sub>15</sub>	GG <sub>15</sub>
4	HHHH <sub>10</sub>	GH <sub>20</sub>	HHGH <sub>10</sub>	GH <sub>21</sub>	HHHH <sub>11</sub>	GH <sub>22</sub>	HHGH <sub>11</sub>	GH <sub>23</sub>	HHHH <sub>12</sub>	GH <sub>24</sub>	HHGH <sub>12</sub>	GH <sub>25</sub>
5	HG <sub>20</sub>	GG <sub>20</sub>	HG <sub>21</sub>	GG <sub>21</sub>	HG <sub>22</sub>	GG <sub>22</sub>	HG <sub>23</sub>	GG <sub>23</sub>	HG <sub>24</sub>	GG <sub>24</sub>	HG <sub>25</sub>	GG <sub>25</sub>
6	HHHG <sub>10</sub>	GH <sub>30</sub>	HHGG <sub>10</sub>	GH <sub>31</sub>	HHHG <sub>11</sub>	GH <sub>32</sub>	HHGG <sub>11</sub>	GH <sub>33</sub>	HHHG <sub>12</sub>	GH <sub>34</sub>	HHGG <sub>12</sub>	GH <sub>35</sub>
7	HG <sub>30</sub>	GG <sub>30</sub>	HG <sub>31</sub>	GG <sub>31</sub>	HG <sub>32</sub>	GG <sub>32</sub>	HG <sub>33</sub>	GG <sub>33</sub>	HG <sub>34</sub>	GG <sub>34</sub>	HG <sub>35</sub>	GG <sub>35</sub>
8	HHHH <sub>20</sub>	GH <sub>40</sub>	HHGH <sub>20</sub>	GH <sub>41</sub>	HHHH <sub>21</sub>	GH <sub>42</sub>	HHGH <sub>21</sub>	GH <sub>43</sub>	HHHH <sub>22</sub>	GH <sub>44</sub>	HHGH <sub>22</sub>	GH <sub>45</sub>
9	HG <sub>40</sub>	GG <sub>40</sub>	HG <sub>41</sub>	GG <sub>41</sub>	HG <sub>42</sub>	GG <sub>42</sub>	HG <sub>43</sub>	GG <sub>43</sub>	HG <sub>44</sub>	GG <sub>44</sub>	HG <sub>45</sub>	GG <sub>45</sub>
A	HHHG <sub>20</sub>	GH <sub>50</sub>	HHGG <sub>20</sub>	GH <sub>51</sub>	HHHG <sub>21</sub>	GH <sub>52</sub>	HHGG <sub>21</sub>	GH <sub>53</sub>	HHHG <sub>22</sub>	GH <sub>54</sub>	HHGG <sub>22</sub>	GH <sub>55</sub>
B	HG <sub>50</sub>	GG <sub>50</sub>	HG <sub>51</sub>	GG <sub>51</sub>	HG <sub>52</sub>	GG <sub>52</sub>	HG <sub>53</sub>	GG <sub>53</sub>	HG <sub>54</sub>	GG <sub>54</sub>	HG <sub>55</sub>	GG <sub>55</sub>

Fig. 18

9/24

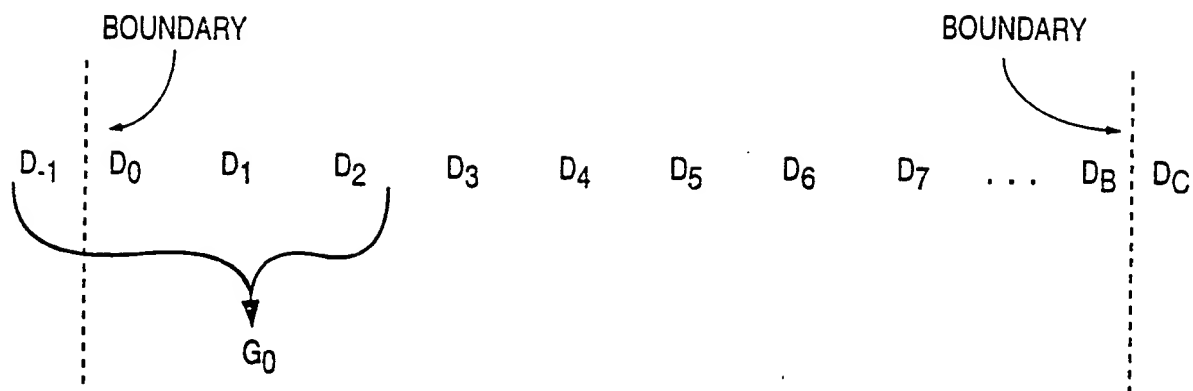


Fig. 19

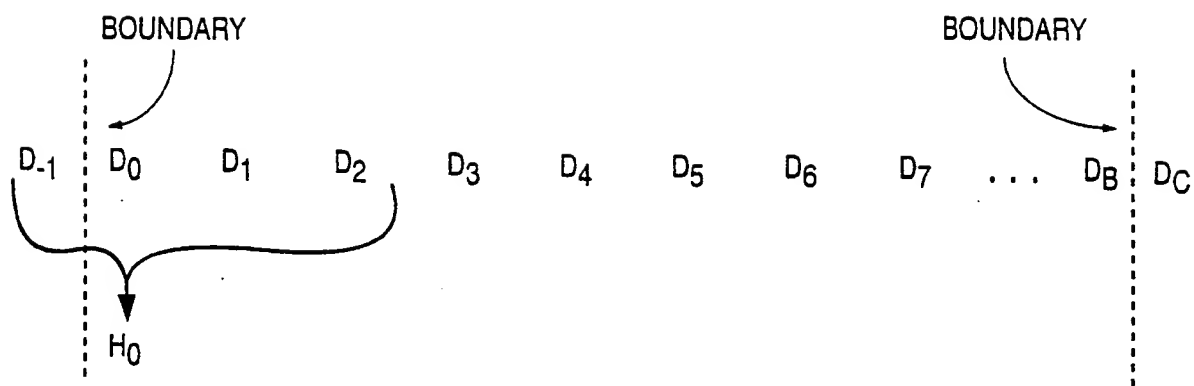


Fig. 20

10/24

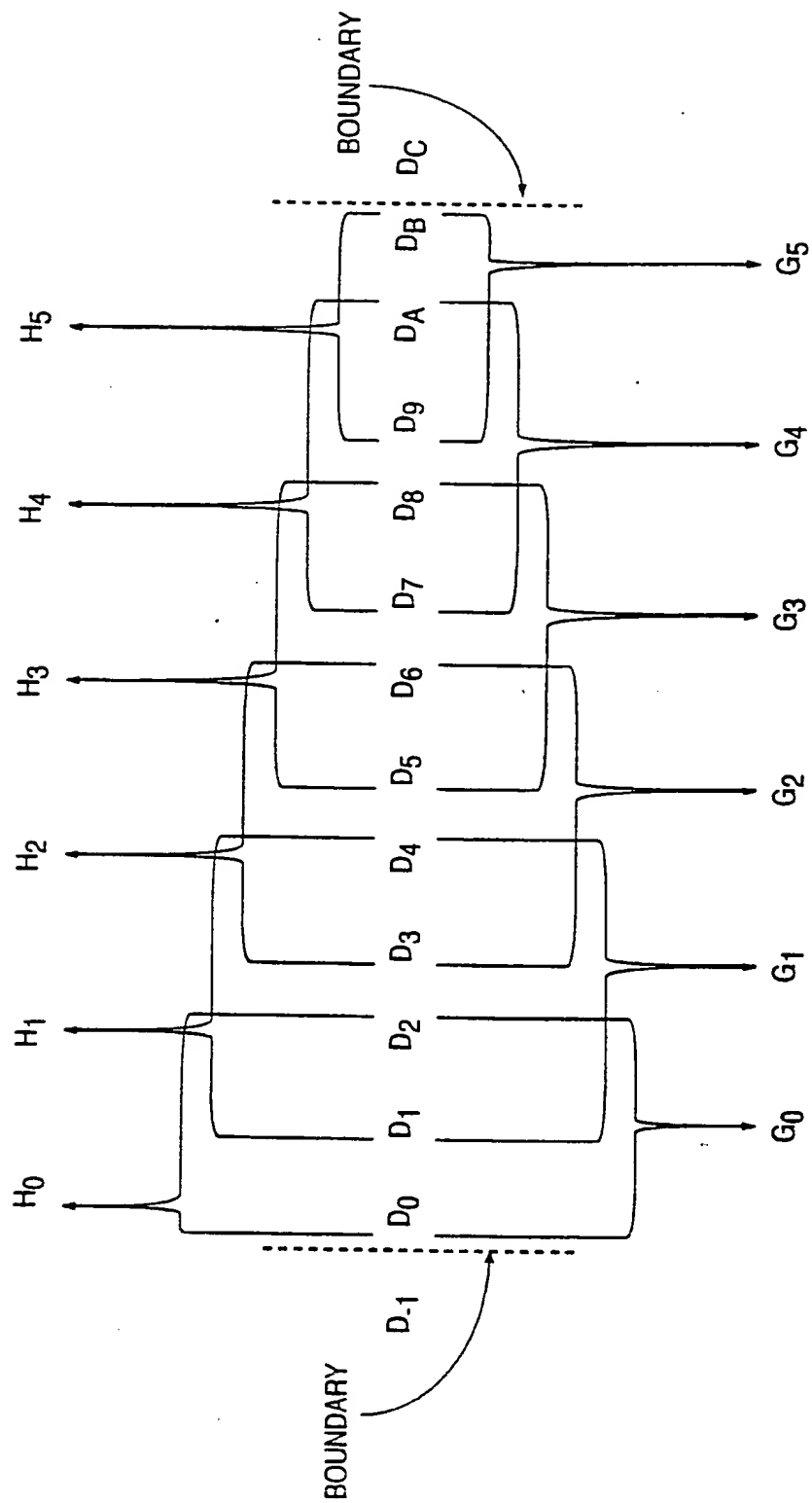


Fig. 21

11/24

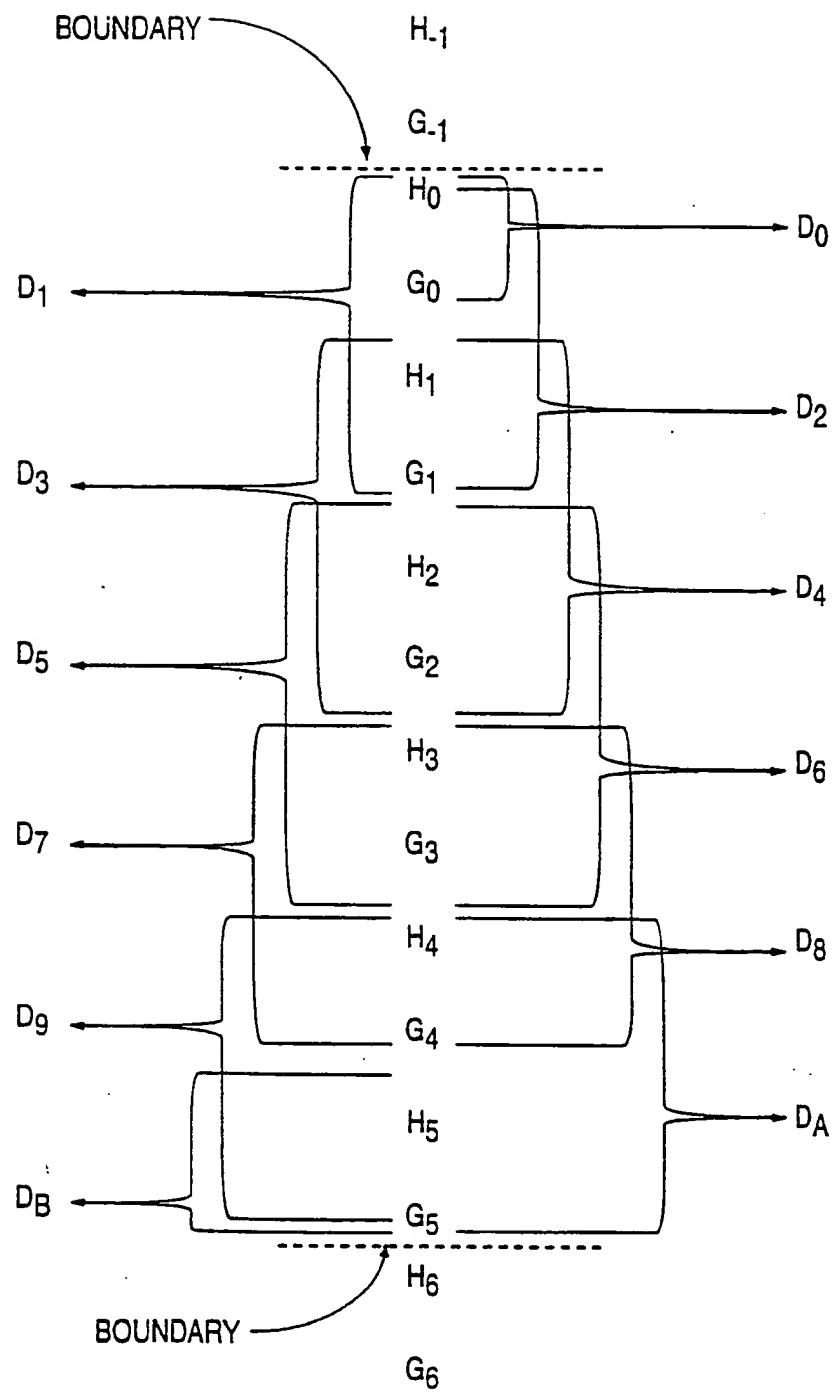


Fig. 22

12/24

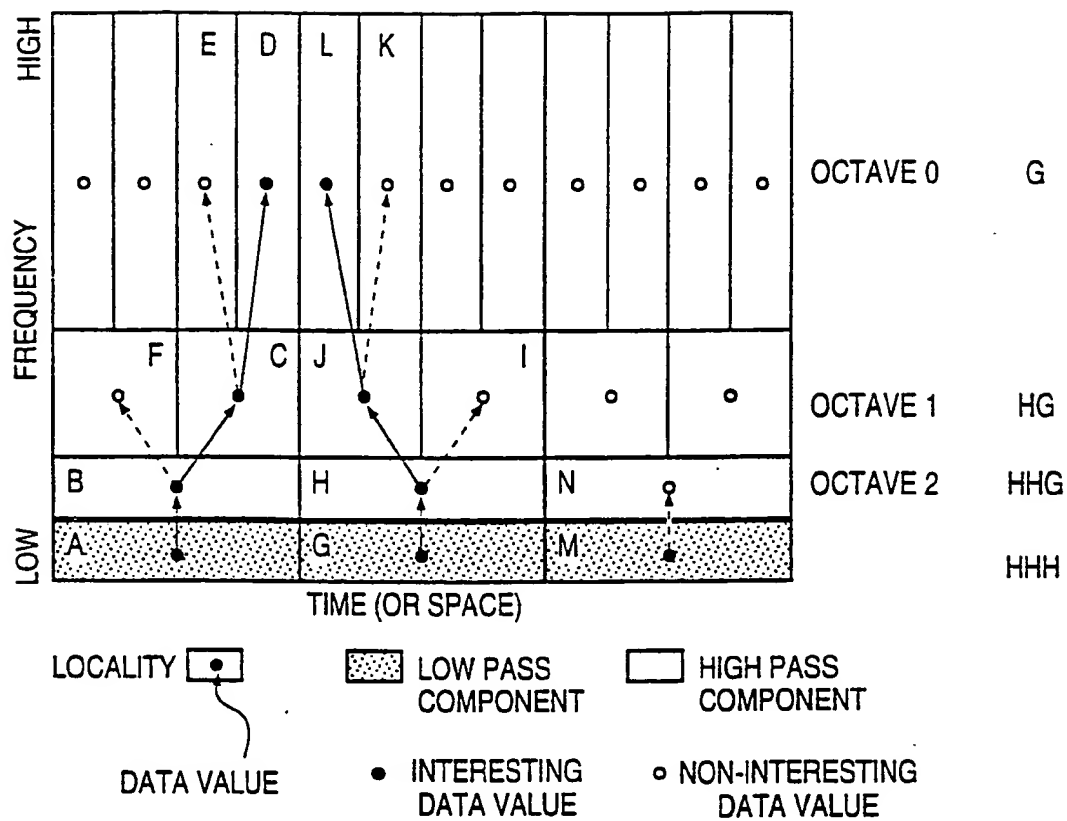


Fig. 23



13/24

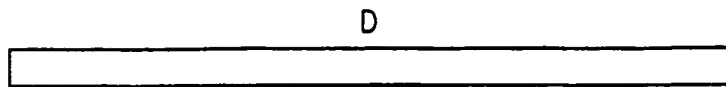


Fig. 24A

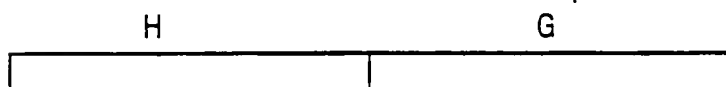


Fig. 24B



Fig. 24C

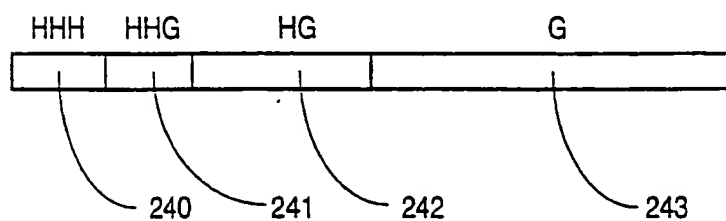


Fig. 24D

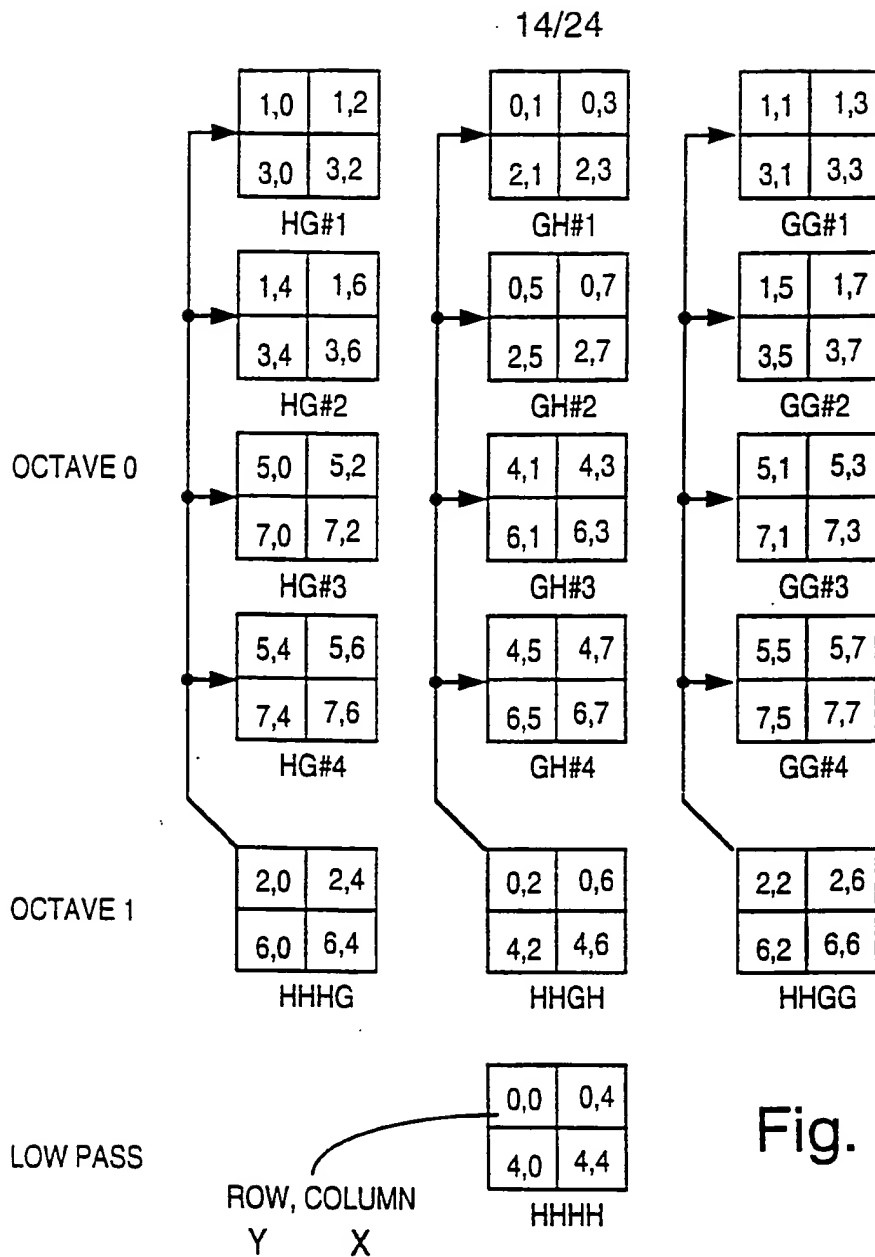
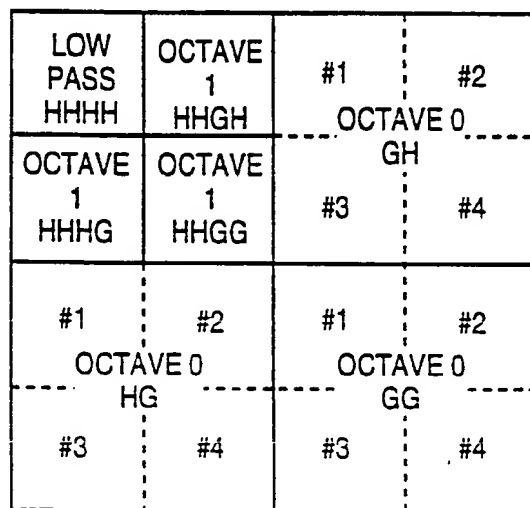


Fig. 25



PICTORIAL REPRESENTATION

Fig. 26

15/24

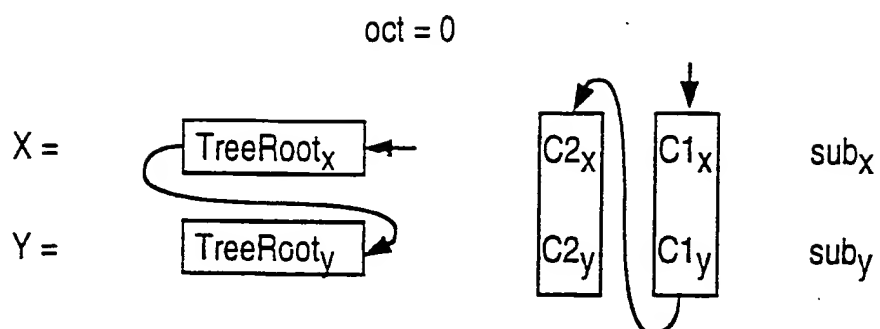


Fig. 27

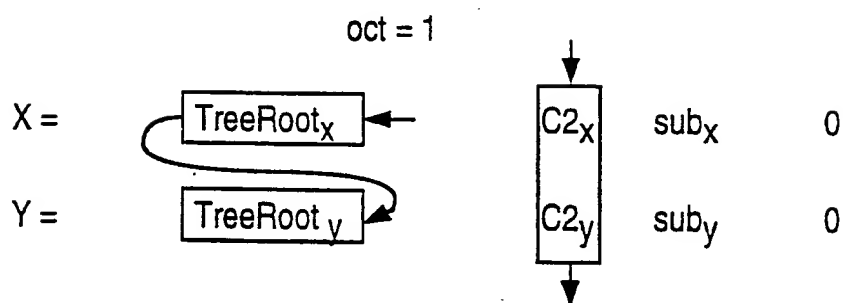


Fig. 28

sub-band		sub <sub>x</sub>	sub <sub>y</sub>
low pass	{ HH	0	0
	{ HG	0	1
high pass	{ GH	1	0
	{ GG	1	1

Fig. 29

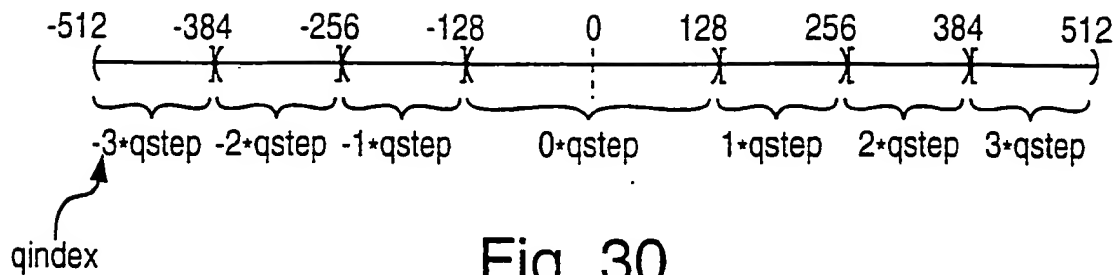


Fig. 30

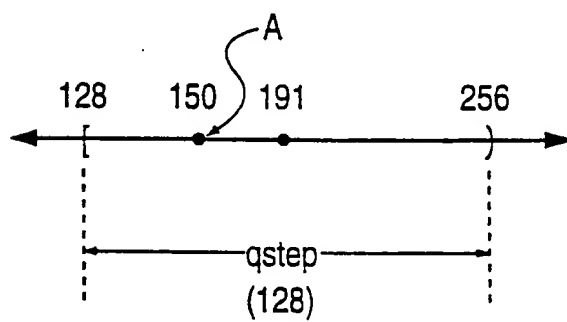


Fig. 31

17/24

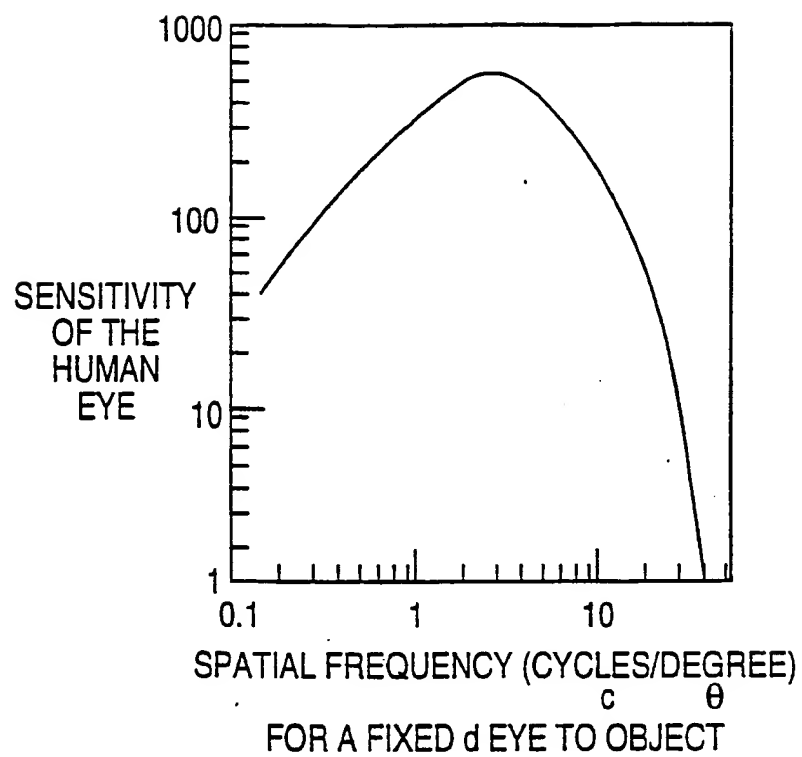


Fig. 32

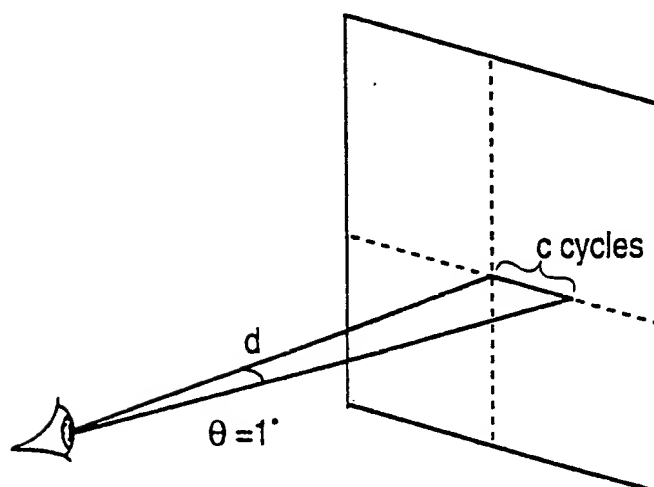


Fig. 33

18/24

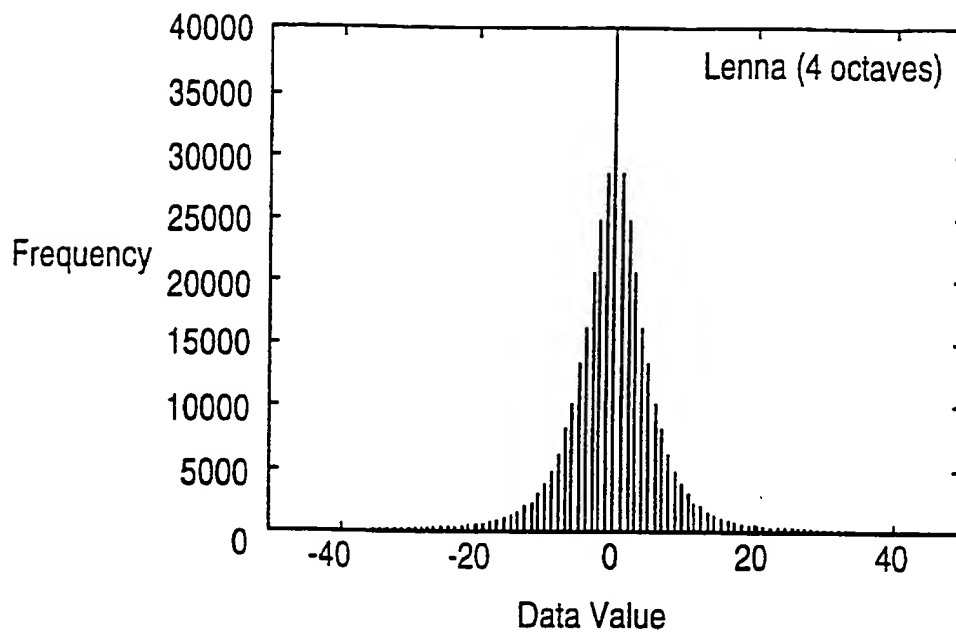


Fig. 34

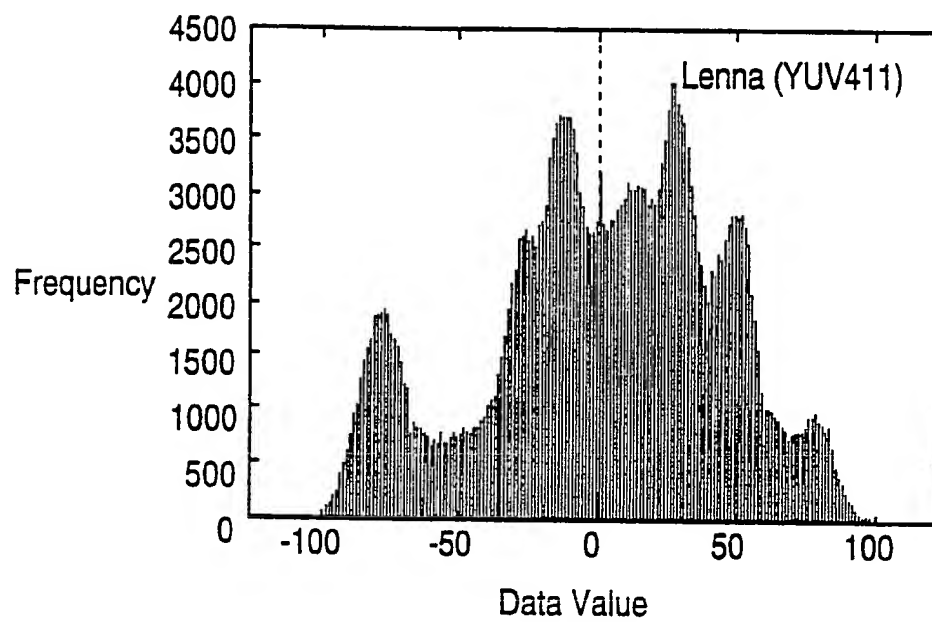


Fig. 35

19/24

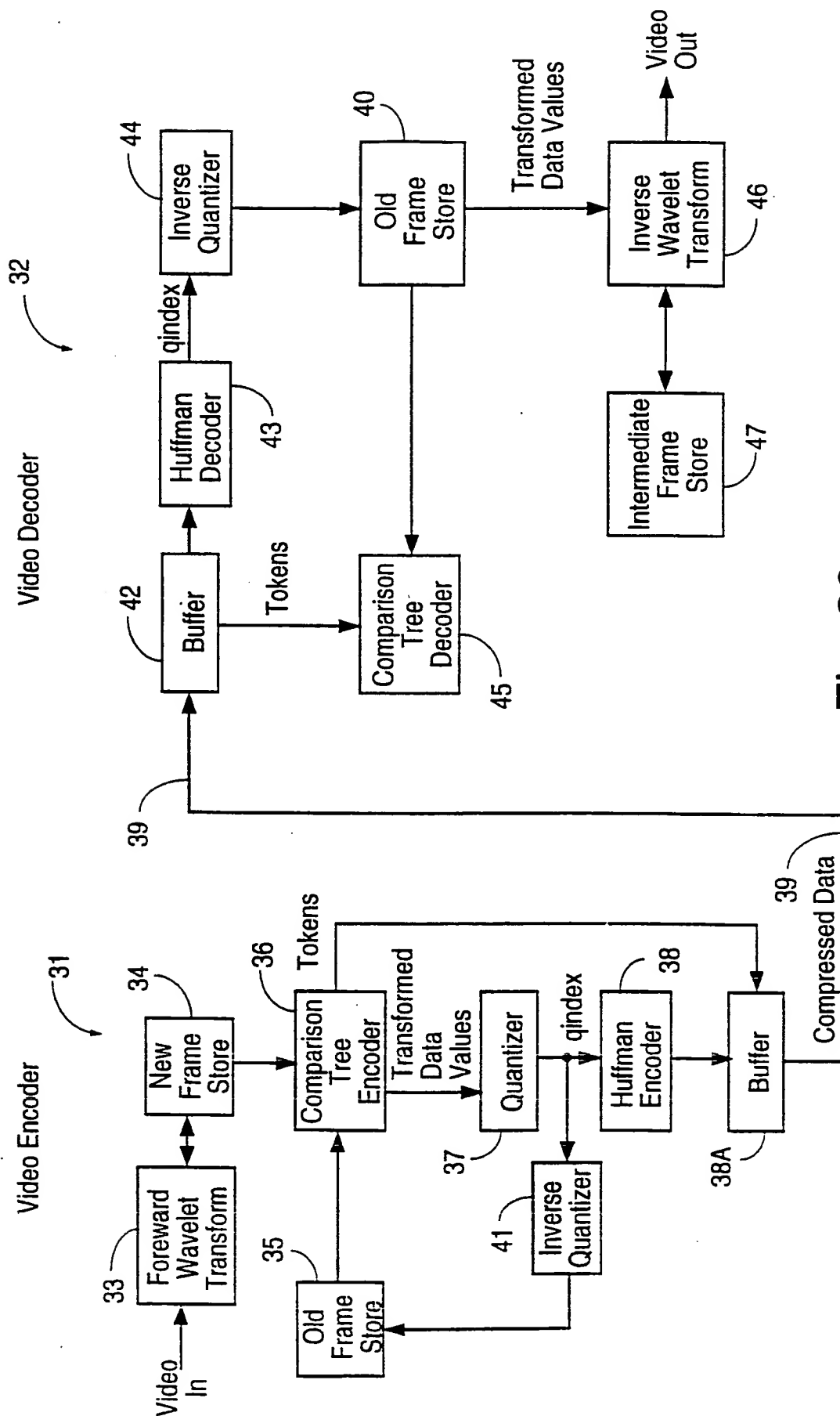


Fig. 36

20/24

# MODES OF VIDEO ENCODER AND VIDEO DECODER

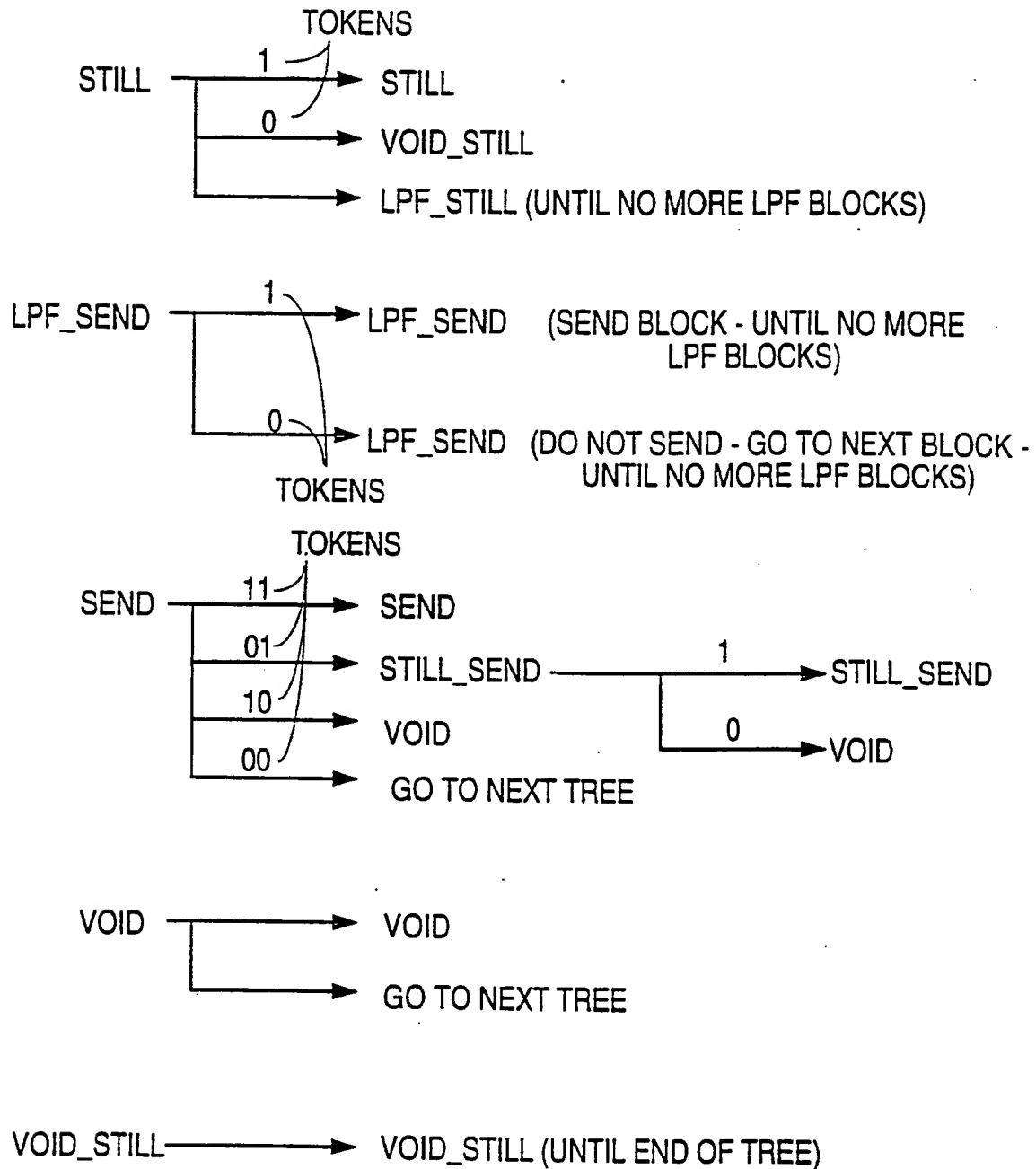


Fig. 37



21/24

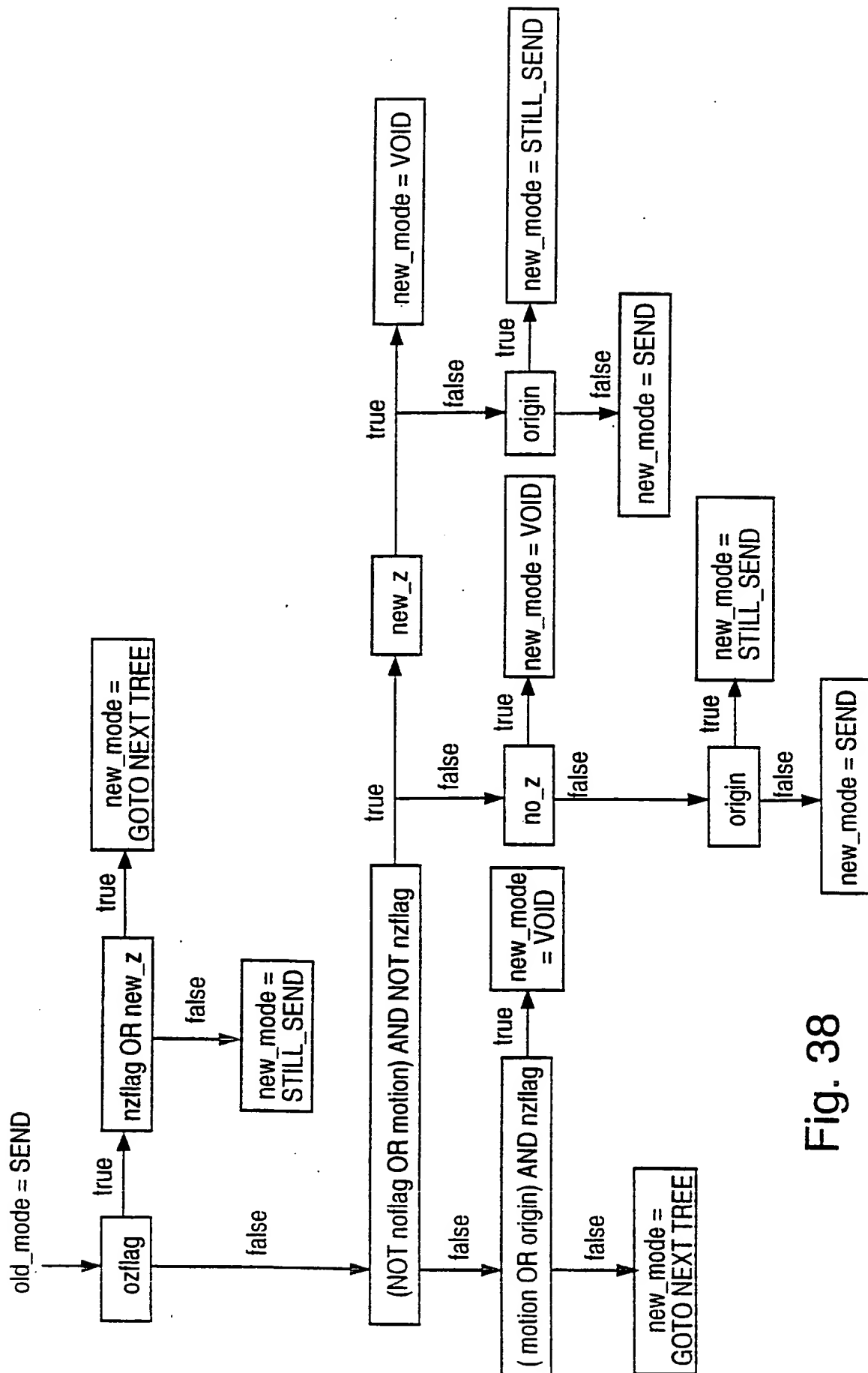


Fig. 38

22/24

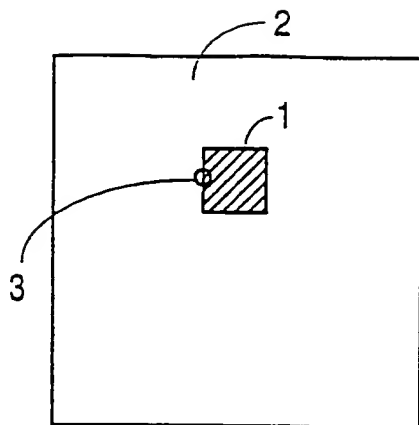


Fig. 39

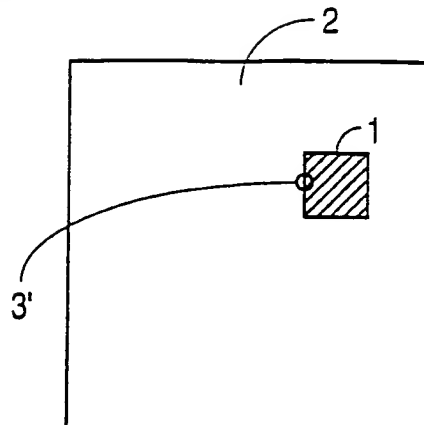


Fig. 40

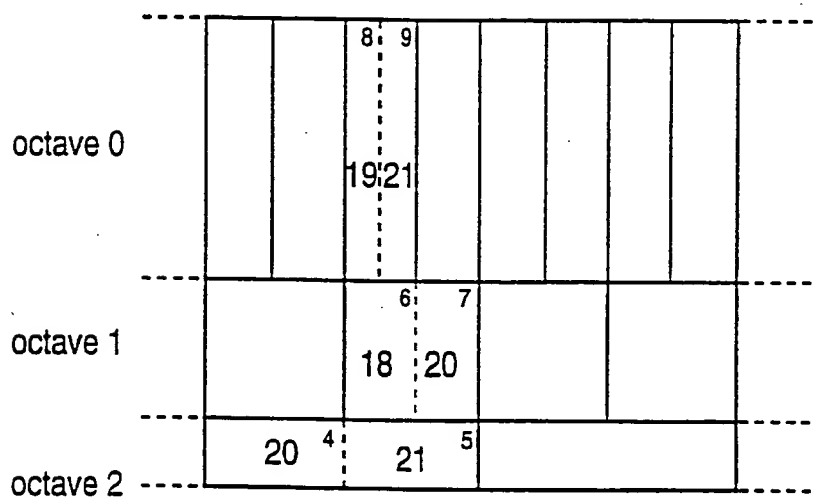


Fig. 41

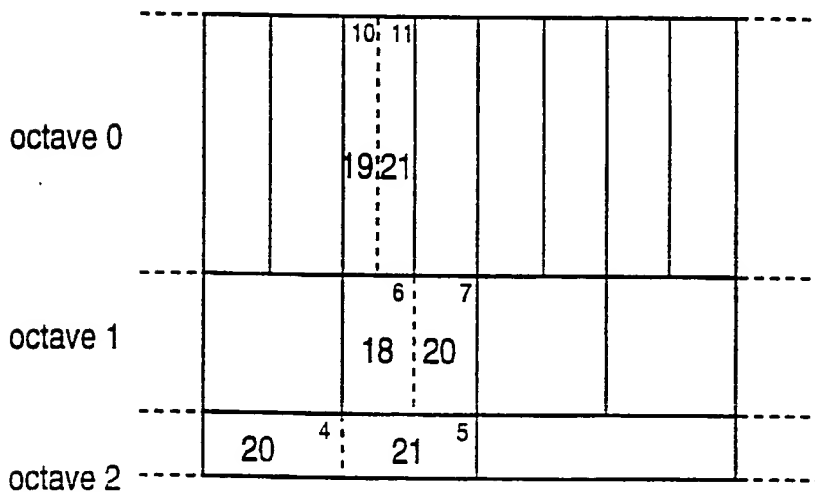


Fig. 42

23/24

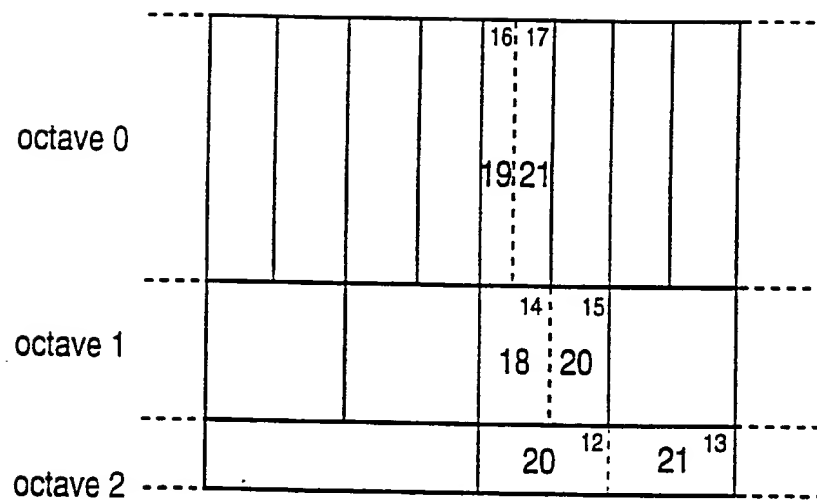


Fig. 43

24/24

## VARIABLE - LENGTH TOKENS

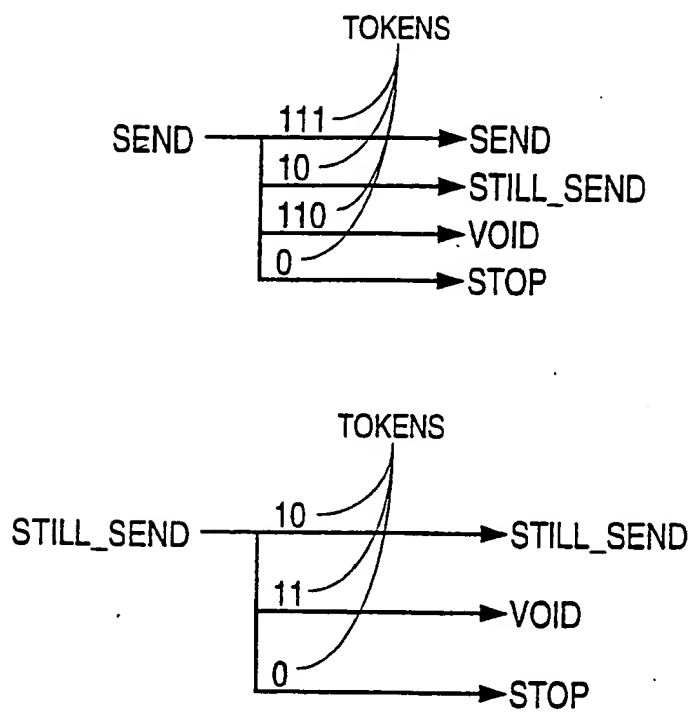


FIG. 44